Sp. Lib.
610.5
S96
G9
v. 104
no. 3

SURGERY
Gynecology & Obstetrics

WITH

INTERNATIONAL ABSTRACTS OF SURGERY

UNIVERSITY OF MICHIGAN
APR 30 1957
HOSPITAL LIBRARY

March, 1957

VOLUME 104 • NUMBER 3

UNIVERSITY OF MICHIGAN LIBRARIES

SURGEONS WITH

"THE FEATHER TOUCH"

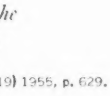
CHOOSE FINER SIZES OF D&G GUT

"Gentleness in handling fragile tissues must be mastered, and the feather touch is essential."

Potts, W. J.: J. A. M. A. 157:627 (Feb. 19) 1955, p. 629.

SURGEONS APPRECIATE the smooth flexible "hand" of D & G gut. They sense the extra knot security offered by D & G's special matte finish.

The rapid trend to the regular use of 000, 4-0 and 5-0 gut in the past five years has brought increased recognition of the values of D & G gut. Special processing assures the most strength with the least gut—unlike ordinary gut which is ground to size with some loss of flexibility and tensile strength.



D & G gut | other gut

The finer sizes of D & G plain, mild chromic and medium chromic gut are, and have been, the acknowledged world-wide standard for gastrointestinal and eye surgery for over twenty years.

When you want to approximate mucous membranes... repair tissues of the neck... ligate small blood vessels . . . or whenever you want to use your "feather touch," check with your O R Supervisor to be sure you have the advantages of finer sizes of D & G gut.

AMERICAN CYANAMID COMPANY
SURGICAL PRODUCTS DIVISION
DANBURY, CONNECTICUT

Advancing with surgery

SURGERY MARCH 1957
Gynecology & Obstetrics VOLUME 104
NUMBER 3

A STUDY OF MOTILITY IN THE GASTRIC REMNANT FOLLOWING SUBTOTAL GASTRECTOMY

GEORGE L. JORDAN, JR., M.D., F.A.C.S., HARRY L. BARTON, M.D., and WILLIE A. WILLIAMSON, M.D., Houston, Texas

THE SYNDROME of gastric retention occurring 8 to 10 days following subtotal gastrectomy commonly has been attributed to stomal edema, with hypoproteinemia, hyperhydration, and hypernatremia being incriminated as contributing factors. However, the fact that some surgeons have found the enteric stoma widely patent at the time of re-exploration has raised a question concerning the validity of this assumption, and many other theories have been advanced. The theory of Prohaska and his associates postulates that gastric atony occurs in the early postoperative period; but a review of the literature failed to reveal definitive data to support this assumption, for very few studies have been made in the early postoperative period —possibly due to fear of disruption of a suture line. One of the more extensive studies is that of Smedal and Conlin who studied 97 patients roentgenographically between 10 and 15 days following subtotal gastrectomy. They noted that the flow and passage of barium out of the stomach remnant was within normal limits, and much the same as seen on subsequent examinations in the later postoperative period, except for an occasional case exhibiting slow emptying; however, they failed to comment specifically on the significance of peristaltic activity in emptying the pouch.

In the intact stomach the rate of evacuation is influenced by antral tone and strong antral contractions which may exceed 100 millimeters of mercury in force, as Quigley has indicated. In the fundus and cardia there is moderate persistent tone, but peristaltic waves are infrequent, feeble, and contribute little to the propulsion of food (Fig. 1). Consequently, following subtotal gastrectomy the gastric remnant consists of that portion of the stomach in which there is very little motility under normal conditions.

The present study was undertaken to elucidate further the degree and significance of motility in the gastric remnant in the early postoperative period following gastrectomy and to evaluate its significance in the syndrome of postoperative retention.

From the Cora and Webb Mading Department of Surgery and the Department of Radiology, Baylor University College of Medicine and the Veterans Administration Hospital, Houston.

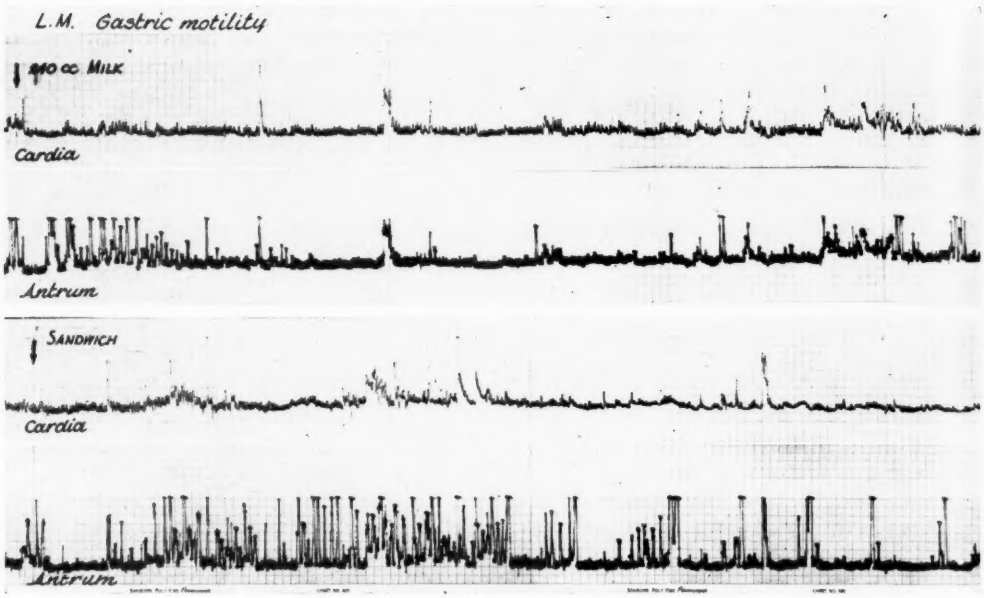


FIG. 1. Simultaneous tracings of the motility in the cardia and antrum of the stomach. The response is shown to milk and to a meat sandwich.

MATERIAL

Forty-six patients were studied between the ninth and fifteenth postoperative days by one or both of the methods to be described. Twenty-three had gastrointestinal continuity re-established by a gastrojejunostomy, of whom 3 were treated for cancer, 3 for benign gastric ulcer, and 17 for complications of duodenal ulcer, while a gastroduodenostomy was performed in 3 patients treated for cancer, 5 treated for benign gastric ulcer, and 15 treated for complications of duodenal ulcer. The surgeon estimated that 70 to 80 per cent of the stomach was removed in 42 patients, 65 per cent in 1 patient, and 50 per cent in another, while in 2 patients the amount of stomach resected was not stated. When gastroduodenostomy was employed, the size of the duodenum governed the size of the stoma as an end-to-end anastomosis was used in all cases. The lesser curvature was closed in all patients treated by gastrojejunostomy, and the usual size of the stoma was 5 to 7 centimeters. In 5 instances the gastrojejunostomy was placed in the retrocolic position, while in the remaining 18 patients the antecolic position was used. In no patient was a vagotomy performed, though 1 patient had previously been treated by vagotomy and gastroenterostomy.

Forty-four patients were asymptomatic at the time the study was done, while 2 exhibited symptoms of gastric retention, in both of whom obstruction was demonstrated roentgenographically to be in the efferent loop just beyond the gastrojejunal stoma. One of these was treated conservatively while the other required operative intervention for relief.

METHODS

Roentgenographic. Forty-two patients were studied roentgenographically. With the patient in the upright position, the stomach pouch was completely filled with barium mixture and observed fluoroscopically for evidence of peristalsis. Films were then taken at intervals of 1, 3, 5, 7, 9, 10, 30, 60, 120, and 180 minutes to measure the emptying

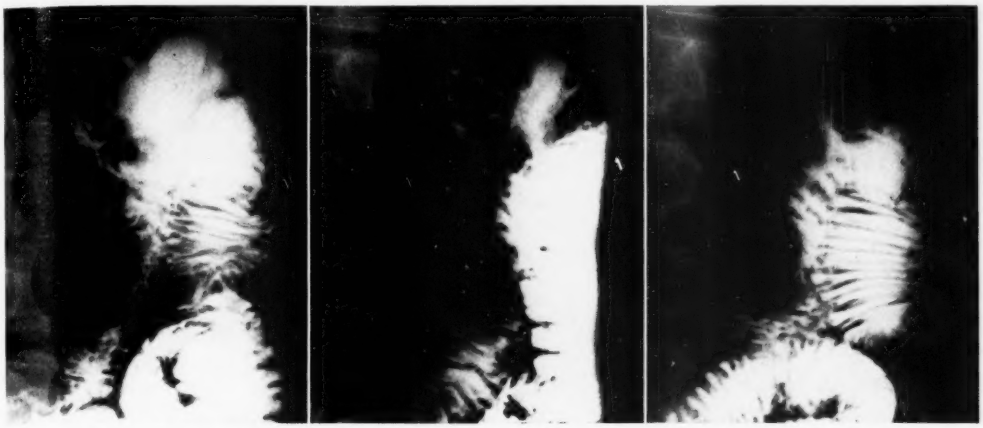


FIG. 2. Roentgenograms showing emptying of the gastric remnant. No active peristalsis demonstrated.

time of the remnant. When emptying was quite slow, roentgenograms were taken at longer intervals. Each of the films was studied for evidence of peristalsis. In 10 patients the study was repeated with the patient remaining in the Trendelenburg position throughout the entire period of observation.

Measurements of intraluminal pressure. Motility was also recorded by measuring intraluminal gastric pressures in 28 patients, 24 of whom had been studied roentgenographically. In 2 instances pressures were measured simultaneously with the roentgenographic examination. The combination of these 2 procedures was excessively complicated, and therefore in most instances they were performed separately, either on the same or on consecutive days. To measure intraluminal pressures, a 2 millimeter radiopaque polyethylene tube was passed into the stomach under radiographic control. After filling the tube with water, it was connected to a Sanborn manometer calibrated so that a change in pressure of 1 millimeter of mercury would result in a 1 millimeter deflection of the stylus of the Sanborn polyviso. A continuous record was made for 1 hour in the fasting state and for an additional hour immediately following the ingestion of a test meal consisting of milk, a meat sandwich, a mixture of milk hypertonic glucose and a prepared fat emulsion, or in some cases a full hospital meal. In 10 of these patients, preoperative studies were made for comparison with the postoperative tracing.

RESULTS

Roentgenographic. The capacity of the gastric remnant varied from patient to patient; however, all were able to ingest at least 10 ounces of barium, and many of them as much as 14 ounces. When barium was ingested it was seen to flow almost immediately through the stoma, and in all except 2 instances (excluding the patients with efferent loop obstruction) there was barium in the intestine when the 1 minute film was exposed. In 2 patients, emptying of the stomach was so rapid that it was impossible to distend the gastric remnant.

The serial films revealed a progressive emptying of the gastric remnant, with a gradual decrease in size as the barium entered the intestine, but in most cases there was no change in contour (Fig. 2). There were only 2 patients in whom a definite weak contraction was visualized roentgenographically. There were 4 additional patients in whom questionable peristalsis was noted. In no patient was a strong contraction observed.

The time required for complete gastric emptying varied from 5 minutes to more

FIG. 3. Roentgenogram demonstrating obstruction of the efferent loop. There is partial filling of the afferent loop.

than 7 hours, excluding the patients with efferent loop obstruction. There were 6 asymptomatic patients in whom more than 3 hours were required for complete gastric emptying. There was a significant difference in the emptying time in patients who had had a gastroduodenostomy as compared to those with a gastrojejunostomy. Following the former procedure the emptying time varied from 30 to 420 minutes with a median of 120 minutes and a mean of 169 minutes. Emptying occurred much more rapidly following the gastrojejunostomy, with the shortest period being 5 minutes and longest 240 minutes. The median was 60 minutes and the mean 76 minutes. A study of the 2 patients with complete efferent loop obstruction demonstrated the point of obstruction satisfactorily (Fig. 3). There was filling of the gastric remnant and the afferent loop, but no peristalsis was noted in the gastric remnant during the period of observation and no barium passed the point of obstruction in the efferent loop at any time.

Eight of the 10 patients in whom studies in Trendelenburg position were compared with studies performed in the upright position demonstrated a prolonged emptying time when the procedure was performed in the headdown position. In each of these 8, emptying took at least twice as long and in 1 instance 4 times as long. However, in 2 patients emptying time was actually shorter in Trendelenburg position than in the upright position.

Intraluminal pressures. The recordings of intragastric pressure were characterized by a minimum of motility. In some patients no gastric contractions were observed during the entire period of observation. However, in most patients there were 6 to 12 contractions ranging from 5 to 15 millimeters of mercury in amplitude during the 1 hour period of observation following the ingestion of the test meal. There were only 3 patients in whom contractions exceeding 15 millimeters of mercury were observed. In 1 of these the contractions measured 20 millimeters of mercury, in the other it was 35, and in the last it was 40; but in none of these patients were more than 3 contractions of this amplitude recorded. Varying the type of test meal had no effect (Fig. 4). The patient with efferent loop obstruction demonstrated the greatest amount of motility; however, all contractions were feeble, and none exceeded 15 to 20 millimeters of mercury. The preoperative and postoperative tracings were similar in each of the patients studied (Fig. 5).

DISCUSSION

The data presented herein indicate that the motility in the gastric remnant is minimal in the immediate postoperative period and is not significantly different from that which occurs in this portion of the intact stomach. The fact that emptying may occur at a rapid rate in the absence of demonstrable peristaltic contractions indicates that emptying of the stump of the stomach is not

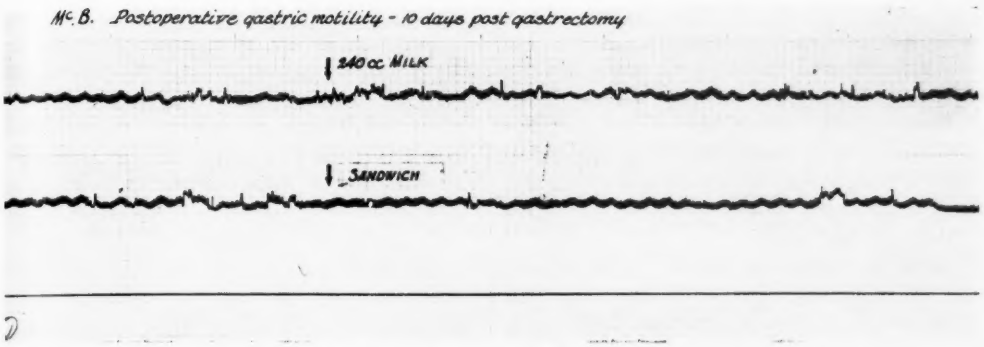


FIG. 4. Tracings of motility in the gastric remnant 10 days postgastrectomy. Minimal response to liquid or solid stimulus.

dependent on propulsive movements of the gastric remnant. Therefore, gastric atony is not a primary factor in the development of gastric retention in the early postgastrectomy period.

The roentgenographic studies allowed some observations on other factors involved in gastric emptying following subtotal gastrectomy. When barium is ingested in the upright position it passes rapidly by gravity directly into the jejunum. When the gastric remnant is filled, that portion of the meal at the stoma is gradually moved on by jejunal peristalsis. As the barium column progresses through the jejunum the remaining barium is displaced from the stump of the stomach with resultant decrease in the size of the stump of the stomach. Coughing, talking, and voluntary changes in intra-abdominal pressure cause small spurts of barium to pass quickly through the stoma as a result of compression on the pouch. Thus, it appears that normal gastric tone, jejunal peristalsis, changes in the intra-abdominal pressure, diaphragmatic motion and gravity are probably the primary factors in emptying the gastric remnant. The significance of gravity is indicated by the slow emptying time in 8 of 10 patients when tested in the Trendelenburg position. The fact that 2 patients did not demonstrate this phenomenon does not obviate its significance, for if the distance between the esophagus and jejunum is short and barium is constantly kept at the enteric stoma, other factors mentioned in the foregoing may allow rapid emptying of the pouch despite the effect of gravity.

The difference in emptying time following gastroduodenostomy as compared to gastrojejunostomy is of interest. The exact reason for this was not ascertained in this study, but factors which might be considered are the size of the stoma, which is usually smaller in a gastroduodenostomy as compared to a

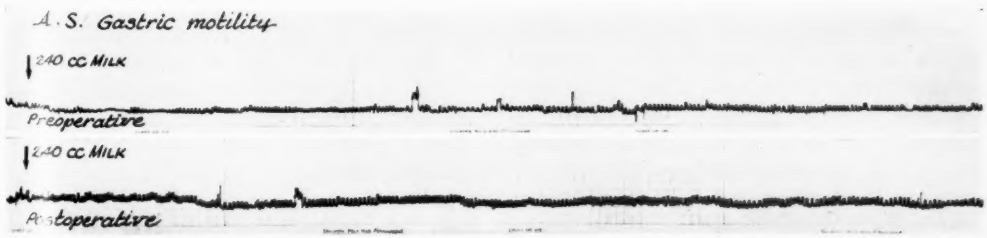


FIG. 5. Preoperative and postoperative records of motility in the cardia of the stomach. Almost complete absence of propulsive movements.

gastrojejunostomy, and the position of the stomach. When a gastrojejunostomy has been performed there is a direct passage from the esophagus straight down to the stoma, whereas after a gastroduodenostomy the stoma lies in a horizontal position so that the effect of gravity is less. Also, it is possible that jejunal motility may be greater than duodenal motility.

Extreme degrees of gastric retention may be tolerated without producing symptoms and it must be emphasized that in the early postgastrectomy period abnormal roentgenographic findings must be correlated with the patient's symptoms if a correct interpretation is to be made. These studies also substantiate those of Moore and Harkins in respect to the difficulty in making a definite roentgenographic diagnosis of marginal ulcer, for in 3 instances this diagnosis was suspected but none of the patients was symptomatic, and all 3 have been followed for a period of several months without clinical evidence of recurrence of disease. Therefore, it was concluded that this syndrome indicated a simple postoperative deformity rather than a true ulcerating lesion, and this conclusion emphasizes the care which must be exercised in interpreting the roentgenographic appearance of a gastrointestinal stoma. As noted before, none of the patients complained of any postgastrectomy symptoms at the time these studies were performed. Therefore, it is apparent that the speed with which the gastric remnant empties is not the most important factor in the development of undesirable postgastrectomy sequelae, and the diagnosis of "postgastrectomy syndrome" cannot be made on the basis of the roentgenologic examination.

On the basis of our studies, it appears that obstruction of the efferent loop is the most common cause of gastric retention following gastrectomy. In this institution the syndrome is not commonly seen, and some patients have been treated conservatively without any attempt to establish the exact site of obstruction. There have been only 4 patients in whom the site of obstruction was accurately determined. Two patients who required reoperation were found to have efferent loop obstruction due to adhesions, and in 2 patients treated conservatively the obstruction was demonstrated roentgenographically to be in the efferent loop. It is to be recommended that all patients showing the syndrome of gastric retention have adequate roentgenographic examinations during the period of symptoms in order that a more accurate determination of the site of the obstruction can be made.

SUMMARY

1. Roentgenographic studies and measurements of intraluminal gastric pressures reveal minimal peristaltic activity in the gastric remnant following subtotal gastrectomy. The normal tone of the gastric wall, jejunal peristalsis, changes in intra-abdominal pressure, diaphragmatic motion, and gravity appear to be the important factors in emptying of the gastric remnant. Consequently, gastric atony is not a primary factor in the development of postoperative retention.

2. In our experience this syndrome has been caused by mechanical obstruction of the efferent loop.

REFERENCES

1. Moore, H. G., and Harkins, H. W. The Billroth I Gastric Resection. Boston: Little Brown & Co., 1954.
2. Prohaska, J. V., Gobostis, M. C., and Kirsteins, H. Mechanism of efferent stoma dysfunction following subtotal gastrectomy. Arch. Surg., 1954, 68: 491.
3. Quigley, J. P. Motor physiology of the stomach, pylorus, and duodenum. Arch. Surg., 1942, 44: 414.
4. Smedal, M. I., and Conlin, W. L. The study of function by roentgenography after the modified Hofmeister resection. Surg. Clin. N. America, 1952, 32: 829.

AUXILIARY MYOCARDIAL VASCULARIZATION BY PROSTHETIC GRAFT IMPLANTATION

SIDNEY SMITH, M.D., MARY BEASLEY, R.N., RICHARD HODES, M.D., HOYT HALL, D.V.M., EUGENE BIEL, M.D., and EDGAR W. HUTH, M.D.,
Bradenton, Florida

THE TECHNIQUE of auxiliary vascularization of the myocardium by direct implantation of an artery is generally credited to Vineberg. The following report is based on experimental procedures on 21 dogs and operation upon 2 human patients.

Essentially this technique consists of grafting a homologous vessel or a prosthetic device, such as a nylon tube, from the aorta into the myocardium. In the earlier series of dogs the homologous carotid artery was used; later "banked" arteries were utilized. Finally, tailor-made nylon prosthetic vessels were used. In all, the technique has remained essentially the same and is accomplished as follows: The graft is anastomosed into the side of the thoracic aorta just below the arch by utilizing the instruments described by Potts and Smith in their original presentation of the aortic-pulmonary anastomosis. The grafted vessel is then permitted to fill with blood to check leaks at the site of the anastomosis and to seal the fabric in the case of the nylon prosthesis. A series of nicks, or small holes, are placed in the vessel, corresponding to the length of the vessel which will be implanted or tunneled into the myocardium. The rationale of nicking the vessel is to provide a number of points for the blood to extravasate into the myocardium. In the case of the nylon vessels these nicks or holes are placed by electrocautery which seals the synthetic material simultaneously with making the hole. This procedure prevents unraveling and, we believe, further insures the continued flow of blood through the holes without clotting. The heart is then lifted out of its pericardial sac, and a probe is advanced just under the epicardium from below the coronary sulcus to the apex of the heart along its comparatively most avascular portion in the myocardial wall toward the apex. At all times the probe is carried just below the epicardium but well within the muscle substance of the left ventricle. The grafted vessel is fastened to this probe by suture material. As the probe is pulled through the heart from the apex, the grafted vessel follows the probe and remains implanted within the myocardium with the nicks, or holes, completely surrounded by the heart substance. The Potts-Smith clamp on the aorta is opened; blood flowing from the apex tip of the graft confirms the patency of the entire vessel. The terminal end of the transplant at the apex of the heart is then trimmed flush with the myocardium and closure of the epicardium over the end of the tube seals the leak. The transplant is also anchored at its insertion to prevent traction of the vessel with subsequent hemorrhage from the nicks in the prosthesis. A pulse in the transplant and a slowly growing hematoma of the surrounding myocardium indicate function of the vessel. This hematoma becomes self-limiting and, we believe, may be the mechanism by which eventual anastomotic channels are established.

As one might expect, the electrocardiogram immediately assumes the characteristic changes of an anterior coronary infarction pattern, corresponding to the currents of injury to that portion of the heart traumatized by the surgery. Recovery from this phase is rapid and will be discussed later in separate articles.

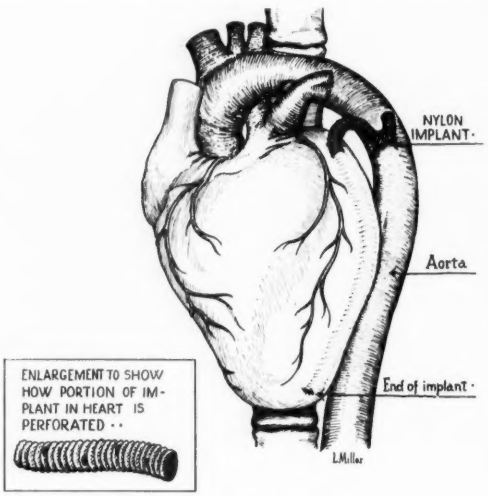


FIG. 1. Technique of operation.

The proof that anastomosis does occur between the grafted vessel and the preexisting normal coronary circulation has been confirmed to our satisfaction by the following experiments. Approximately 3 months after initial surgery, and, in 1 case, 1 year after the initial surgery, the animal was reoperated upon under anesthesia, and a dye mixture of diodrast and fluorescein was injected. The transplant vessel was first clamped at its origin from the aorta to prevent backflow into the general systemic circulation, the lights in the room were turned out, and ultraviolet light was used to follow the progress of the fluorescein. The coronary circulation of the dog became fluorescent immediately upon injection of the dye into the transplant; it is assumed that this is the venous return circulation. Next, fluorescence occurred in the lungs, and, approximately 2 minutes from the time of the initial injection, the fascia lata of the hind legs began to glow under the ultraviolet light. The indication was that the fluorescein progressed from the transplant artery into the myocardial substance, anastomosed with the coronary circulation, to return by way of the coronary veins into the coronary sinus which empties into the right auricle between the inferior vena cava and the auricular ventricular opening. From the right side of the heart the dye entered the lungs, causing them to become fluorescent, and from the pulmonic circulation it returned to the left side of the heart and ended in the peripheral tissues in about the time normal circulation had been previously calculated to exist.

A second method of checking the circulation was by visual observation by x-ray technique. This procedure was best accomplished after excision of the heart. Again the diodrast was injected into the transplant and x-ray films were taken (Figs. 2, 3, and 4). In Figure 2 the dye pooling at the end of the artery occurred in one of the earlier experiments before the nicks, or holes, were placed along the course of the vessel, and, in fact, this observation led to the decision to make many openings in the vessel to provide connections along its course. Figure 3 shows the more extensive vascularization in a subject in which a number of openings were made along the course of the implant. Figure 4 shows the same heart with injection of the normal coronary vessels. It is interesting to note that filling of the venous tree also backs up into the transplant which, we believe, indicates a free anastomosis between transplanted segment and normal venous drainage.

The third method of proof is purely experimental. After the proof of circulation had been established in our minds, a preliminary operation was made on a number of dogs in which a descending branch of the anterior coronary was ligated. In the dogs surviving ligation of the anterior descending branch of the coronary, the experimental procedure was accomplished 3 days later. In a series of approximately 5 dogs in which this procedure was accomplished, the animals, following ligation, had remained in their kennels without any activity, refusing even to eat. Following the second procedure they became active immediately upon awakening, began to eat their food on the morning following surgery, and thereafter were very active. At postmortem examination these

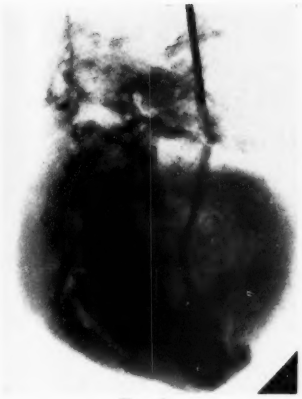


FIG. 2.

FIG. 3.

FIG. 4.

FIG. 2. A year after surgery. Diodrast injected into graft.
FIG. 3. Dog heart 1 year after surgery. Diodrast injected into implant to visualize auxiliary circulation.

FIG. 4. Same dog heart as in Figure 3 with normal coronary circulation injected with diodrast for comparison study.

dogs did not show any marked infarction by gross examination, apparently the existing collateral circulation being sufficient to maintain the life of the muscle but insufficient to maintain myocardial efficiency. These dogs tended to howl and required morphine sedation. The presumptive opinion is that they were suffering "angina" which was relieved following the experimental procedure. The reverse of this procedure was also performed; namely, creating an auxiliary vascularization followed by ligation of the descending branch of the coronary at a point high enough in its origin normally to cause death of the animal. This procedure is still under experiment and will be reported when more evidence has been acquired.

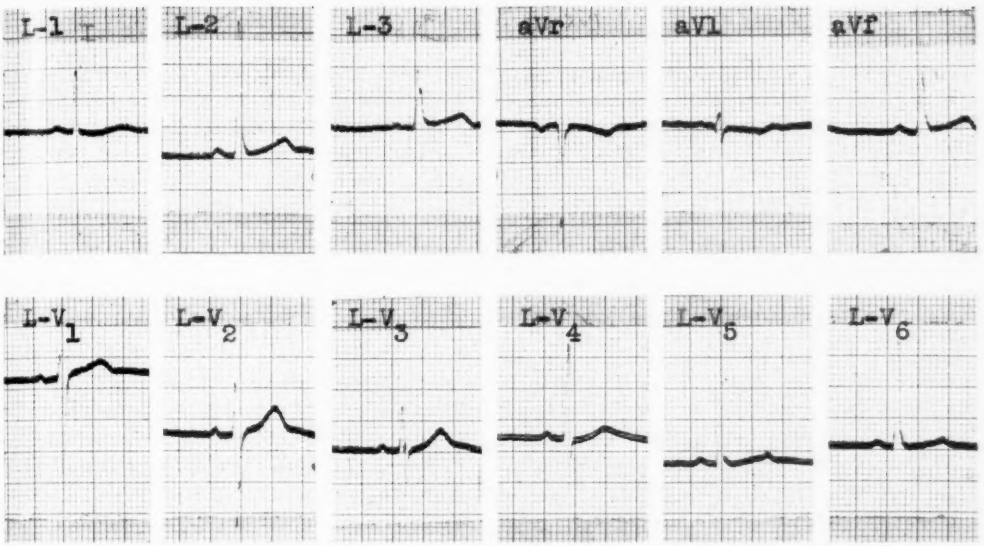
On the basis of these 3 experimental observations, namely, the fluorescein dye, diodrast x-ray films, and the laboratory return to activity, we believe that definite proof of the anastomosis of the graft with the existing coronary circulation can be demonstrated, as originally propounded by Vineberg. Furthermore, we believe that the graft is large enough to enable the surgeon to make many points of egress of the blood along the course of the graft, a procedure which is not feasible with a small implant, such as the internal mammary artery. On the basis of this evidence we felt justified in applying this procedure to a human subject.

CASE HISTORY

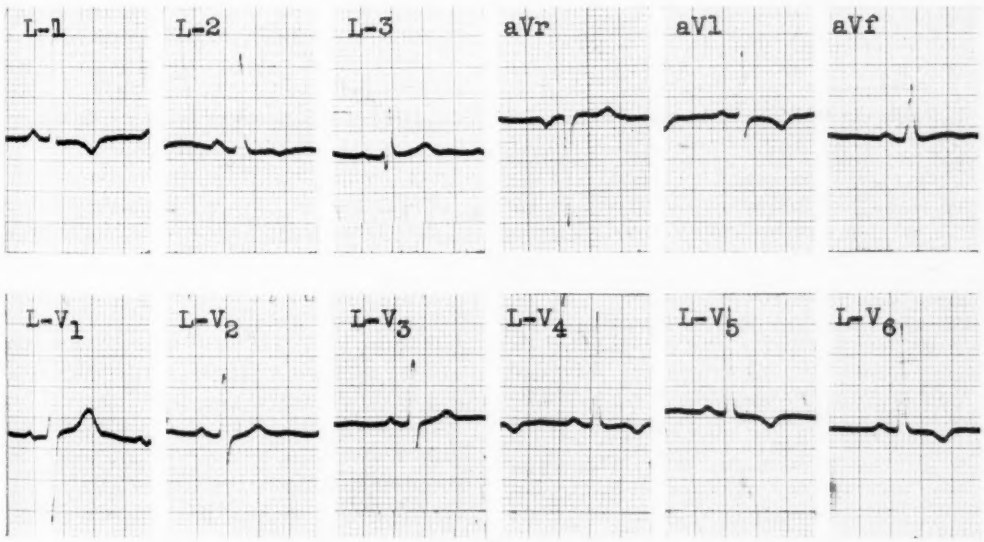
CASE 1. The first patient, C. DeS., a 43 year old male, gave a history of onset of angina approximately 8 months before, and, when first seen, was taking 2 tablets of peritrate, 4 times daily, hormone therapy, lipotropic substances, and he was dependent upon nitroglycerine, 1/100, of which he used as many as 20 a day. He owned and managed a supermarket grocery store. The past few months he had found he was unable to do any work in the store and was attempting to manage it by remote direction. In addition, he confided that he was unable to perform the functions of a husband. The sex act precipitated severe anginal attacks, which precluded any marital relationship. His electrocardiogram was consistent with a diagnosis of anterior coronary insufficiency and a Master's test done in confirmation was stopped before completion because of severe anginal pain requiring immediate use of nitroglycerine. The changes in the ST segment were in accordance with the onset of anginal pain and were typical for severe anterior wall ischemia. Revascularization of the heart was discussed from the surgical standpoint. The various methods now in use were outlined, including, of course, the method we had developed in the dogs. The patient elected to accept the risk of being the first human patient to undergo surgery by the method reported herein. Surgery was performed on October 4, 1955. In this case the external saphenous vein was found to be large enough to be used as a transplant, and the saphenous vein from the groin to the knee was carefully removed just prior to the actual heart surgery. Under gas oxygen intuba-

FIG. 5. Electrocardiograms, Case 1. a, Before surgery; b, 6 months after operation.

tion anesthesia, the grafting of the vessel was accomplished as described in the experimental work. Constant electrocardiography was performed during surgery. The patient stood the procedure well and was awake at the end of the operation. Immediately after implantation of the vessel the inversion of the T waves, corresponding to the injury pattern of an anterior coronary, developed and the patient began to show the typical clinical signs of a coronary occlusion with a dropping blood pressure. Preoperative blood pressure was 160/90 with an oscillometric index of 5 and a rate of 72. Minimum blood pressure occurred approximately 12 hours after surgery at which time the pressure dropped to 90/70 but began to make a return to higher levels within a few hours of supportive treatment and within 24 hours was back to 135/90. The



a



b

FIG. 6. Electrocardiograms, Case 2. a, Before surgery; b, 6 months after operation.

patient was followed with serial electrocardiograms on a daily basis during his stay in the hospital and subsequently, after his discharge ambulatory on the fourteenth postoperative day, on a 2 to 3 week basis for the following 6 months. A detailed description of the electrocardiographic changes will be described at a later date, but it can be summarized as follows: within 3 months the previous T wave changes had reverted to normal, and, in addition, all evidence of anterior coronary ischemia was gone, both on resting and on Master's tests. The patient returned to full activity in his store and at the present time is working a full 10 hour day followed by normal recreational activity with his children. As a follow-up, he states that his marital sex life has returned to normal and is satisfactory.

CASE 2. The second patient, C. E. W., a 50 year old male, was first seen on September 15, 1955. This man also is a manager of a supermarket grocery store. He stated that his anginal symptoms had started 5 years ago, had been progressively getting worse, and he had been advised by medical attendants that maximum benefits had been attained and that he should consider revascularization of his heart by the surgical techniques available. His Master's test confirmed the impression of marked anterior lateral coronary ischemia but he was kept on a medical regimen for a period of some months to observe further before a decision was made to subject him to surgery. The progressive symptoms, despite what was considered adequate medical care, convinced us that surgery would be desirable. This patient also elected to accept our technique and was operated upon on June 27, 1956. He was much smaller in stature than the patient in Case 1, and it was found that his saphenous vein would not be adequate. On the basis of our experimental work we were quite confident in the use of the nylon arteries provided an acceptable commercial preparation of the same were available. Our first shipment of the commercial preparation of the nylon prosthetic arteries had been received 2 days prior to this operation. These nylon arteries were 3/16 inch in diameter and were cut to required length by the technique outlined by Edwards. Openings were made along the course of the prosthesis by electrocautery in the portion that would be imbedded in the heart. The rest of the surgery was identical to the procedure outlined in the experimental phase of the surgery. As in the previous case, continuous electrocardiography was done throughout the actual tunneling of the artery into the heart, and again the electrocardiographic findings were identical to those described for the patient in Case 1. The use of the nylon prosthesis definitely reduced the time of surgery, the total time being 1 hour and 50 minutes skin to skin. In this case also the patient was awake at the close of the operation. Unlike our first patient, the drop in blood pressure was not so great, although the electrocardiographic findings were identical, and the postoperative recovery course was more benign. A very interesting observation occurred on the fifth postoperative day. This patient was subject to bad dreams and invariably was awakened by his nightmares with severe angina, requiring nitroglycerine. On the fifth postoperative day he had one of his nightmares which awakened him, but he did not have angina. He had not been under heavy, or even moderate, sedation by morphine nor any of the other drugs which are normally used in coronary management. Although this patient's postoperative course was more benign he was held in the hospital longer to study the effect of the nylon prosthesis on his electrocardiograms. He was discharged ambulatory on the sixteenth postoperative day. On the basis of experimental work and previous clinical observations completed over 6 months ago, this patient should also have an excellent result.

COMMENT

It is not in the province of this report to attempt to discuss the various probabilities or possibilities of how Nature provides an anastomosis between a grafted vessel implanted directly into the myocardium, with the resultant union with the venous drainage. Serial sections by our microscopists do not shed light on the method of communications. Knisely suggested using liquid lucite of three colors: one color to be injected into the coronary artery circulation, another color to be injected into the grafted circulation, and a third color to be injected retrograde into the venous circulation. After the plastics solidify, the muscle substance can either be digested from the plastic matrix or clarified in a suitable solution to permit visualization of the combination of the three colors which will outline the circulation. This constitutes a research problem in itself and will be undertaken soon. At present, we are satisfied that the auxiliary circulation is created and that this circulation does relieve the clinical and electrocardiographic manifestations of coronary insufficiency.

SUMMARY

A technique of direct implantation of a synthetic artery, or blood vessel bank artery, from the aorta into the myocardium of the heart, has been described. This technique is a modification of a method originally described by Vineberg and, to a certain extent, a method modified from the Beck No. 2 operation. The instruments used for the most part are those standard cardiovascular instruments originally designed by Willis Potts and Sidney Smith.

REFERENCES

1. BECK, CLAUDE S., HAHN, RICHARD S., LEIGHNINGER, DAVID S., and MCALLISTER, FERDINAND F. Operation for coronary heart disease. J. Am. M. Ass., 1951, 147: 1726-1731.
2. EDWARDS, W. STERLING. Personal communication.
3. POTTS, WILLIS J., SMITH, SIDNEY, and GIBSON, STANLEY. Anastomosis of the aorta to a pulmonary artery in certain types of congenital heart disease. J. Am. M. Ass., 1946, 132: 627-631.
4. VINEBERG, A. M., and JEWETT, B. L. An anastomosis between coronary vessels and transplanted internal mammary artery. Canad. M. Ass. J., 1947, 56: 60.

THE LYMPHATIC SPREAD OF CANCER OF THE STOMACH OBSERVED IN OPERATIVE SPECIMENS REMOVED BY RADICAL SURGERY INCLUDING TOTAL PANCREATECTOMY

ROBERT E. L. BERRY, M.D., F.A.C.S., and WILLIAM ROTTSCHAFER, M.D.,
Ann Arbor, Michigan

THE SURGICAL EXCISION OF CANCER of the stomach remains the only known effective method of dealing with this disease. Five year survival rates, however, are poor. Of 1,370 patients in whom the diagnosis of gastric cancer was made at the University of Michigan Hospital between the years 1935 to 1950 only 8.1 per cent were alive at the end of 5 years. Nine hundred and eighty of them were dead within 10 months after the diagnosis was made. The acquisition of greater surgical knowledge and utilization of bolder operative attack have been disappointing in providing significant increase in long term survival rates. A comparison of two large series of cases of cancer of the stomach, Mayo's (2) early in this century (1919) and Pack's near the midpart (1948), revealed only a 10 per cent increase in the 5 year survival rate, following operative removal, in the latter series.

The evolution of total gastrectomy and multiple organ excision for cancer of the stomach has followed improved knowledge of preoperative preparation, the availability of large whole blood replacement during operation, greater safety in prolonged anesthesia, and the well intentioned desire of surgeons to improve the admittedly poor salvage rate of these neoplasms. A limited number of fortunate individuals have been benefited by such procedures and lead relatively normal lives apparently "cured" of their cancer. The majority of patients undergoing these operations, however, are indeed less fortunate. For them longevity has not been significantly increased, palliation is poor because of nutritional disturbances imposed by resection of all or the greater part of the stomach, and it is well recognized that the operative mortality and postoperative morbidity are increased when compared to the "conventional" subtotal resection.

The routine use of total gastrectomy for all cancers of the stomach has been periodically reported and recommended. This approach has not gained wide acceptance for perhaps two important reasons: (1) there is no convincing evidence that routine total gastric resection is superior to a radical subtotal as a potential method of cure; and (2) higher operative mortality and postoperative morbidity rates are attendant to total gastrectomy.

The majority of total gastrectomies and multiple organ excisions for gastric cancer are done because it is the only method by which the gross tumor can be removed. As a corollary, the removal of increasingly large blocks of tissue should be concomitant with a greater excision of potentially involved lymph nodes. Although such lymph node excision continues as integrative rationale of good cancer surgery, it should not detract from the increasing awareness that the prognosis of cancer of the stomach may well be related to the biologic malignant potential of the cells of a given neoplasm more than any other factor.

This report deals with the lymphatic spread and clinical history of 7 advanced cancers of the stomach which had invaded the body and head of the pancreas. Five

Supported by a grant from the Horace Rackham School of Graduate Studies of the University of Michigan.

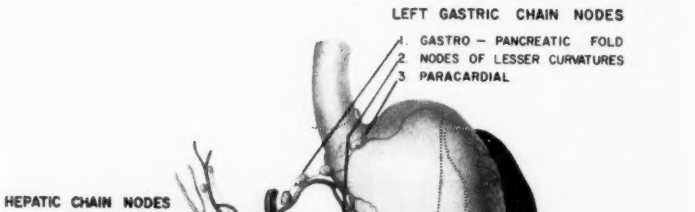


FIG. 1. Schematic diagram of the lymph node drainage of the stomach adapted from Rouvière. The three principal chains (left gastric, hepatic, and splenic) are intimately associated with their concomitant arteries. Areas of drainage of lymphatics of the abdominal wall are also outlined. The left gastric chain nodes receive lymphatics draining the lesser curvature and right half of the cardiac end of the stomach. Hepatic chain nodes receive the lymphatics of the lower half of the greater curvature and both suprapyloric and infrapyloric areas. Splenic chain nodes receive drainage from the upper half of the greater curvature and left cardiac portions of the stomach. Lymphatic spread of cancer of the stomach does not always follow such conventional lines.

operative specimens consisted of tissues excised by en bloc removal of the great omentum, total gastrectomy, total pancreaticoduodenectomy, and splenectomy. The celiac nodes of the preaortic chain were included. Two specimens consisted of removal of similar tissues except that pancreatic excision was limited to 80 per cent and the duodenum was left intact.

PREPARATION OF SPECIMENS

Fresh specimens were immediately perfused with a 1 per cent sodium citrate solution by tying small cannulas into the cut ends of the left gastric, splenic, and gastroduodenal arteries. After 1 to 3 hours the specimens were relatively bloodless. Fixation in 10 per cent formalin for 24 to 48 hours followed. Tissue dehydration was then accomplished by consecutive passage through 50, 60, 70, 90, and 95 per cent alcohol, and finally absolute alcohol. Each stage usually required 24 hours. Final clearing was accomplished by immersion into methyl salicylate. Because of the thickness of tissue mass repeated change of the methyl salicylate was necessary, and as long as 7 to 10 days were required for satisfactory clearing and transparency. The lymph nodes were then individually removed, labeled as to location, and prepared for microscopic examination with hematoxylin-eosin stain.

LYMPHATICS OF THE STOMACH

The wall of the stomach is richly provided with lymphatics. The intramural system consists of three networks: submucosal, intermuscular, and subserosal. Not only do these lymphatics communicate freely with themselves but also have direct access to the lymphatics of the upper duodenum and lower esophagus. The lymph nodes receiving the egress of these lymphatics are closely associated with the arterial supply of the stomach and consist of four major divisions (Figs. 1 and 2).

Left gastric group. This is the most important group and consists essentially of three divisions: (1) The upper group found along the main stem of the left gastric artery between its origin and the lesser curvature of the stomach. Usually 1 to 3 in number they are found in the gastropancreatic fold above and behind the left gastric vessels. (2) The lower group closely associated with the major branches of the left gastric artery. These may be present in large numbers but rarely extend beyond the midpoint of the cardiac and pyloric ends of the stomach. (3) The parietal group and nodes of the pars cardia. Intramuscular or subserous in position and varying in number they may form a necklace about the esophageal cardiac junction.

Hepatic group. The hepatic group consists of: (1) the nodes along the main stem of the hepatic artery, usually 1 to 4 in number; (2) the gastroduodenal group (retropyloric nodes), usually 1 to 3 in number, located between the duodenopyloric wall and the pancreas; (3) the infraduodenopyloric group (subpyloric nodes), usually 2 to 3 in number may at the same time be retropyloric as well as infrapyloric; (4) the right gastroepiploic group (inferior gastric nodes), varying from 1 to 11 in number, located along the right half of the greater curvature; (These nodes drain into the infraduodenopyloric nodes.) (5) the right gastric group (suprapyloric nodes), usually 1 to 3 in number, accompanying the right gastric branch of the hepatic artery; (6) the pancreaticoduodenal group, located between pancreas and duodenum the anterior nodes (3 to 6) draining into the infrapyloric nodes, the posterior nodes (2 to 4) draining into the preaortic nodes about the origin of the superior mesenteric artery as well as into the hepatic chain nodes.

Splenic group. The splenic group consists of: (1) the suprapancreatic nodes, usually 3 to 4 in number, but possessing great variability. (Nodes along the main stem of the splenic artery are more constant. At times 1 to 3 nodes may be in the gastric-splenic ligament—pancreaticolienal nodes. As many as 8 nodes may be found between the origin of the left gastroepiploic artery and the greater curvature. Instead of a chain there might be a lymph node aggregation.) (2) The infrapancreatic nodes, situated below the tall and lateral part of the body of the pancreas. (Not all nodes in this area may belong to this chain. The most medial at the duodenal-jejunal angle belong to the superior mesenteric nodes and drain into the intestinal lymph chain and the celiac nodes.)

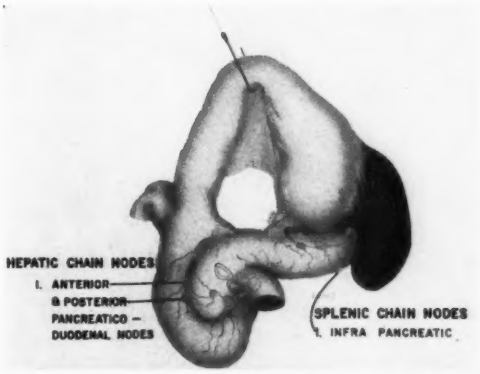


FIG. 2. Lymphatics of the pancreaticoduodenal loop and infrapancreatic lymph nodes. (Adapted from Rouvière.)

Celiac nodes. The celiac nodes are usually 1 to 3 in number. Often they are related more extensively to the left gastric and hepatic arteries than to the celiac axis and preaortic node chain.

RESULTS

For purposes of identifying the anatomic location of the removed lymph nodes, 9 areas were designated as follows: areas 1–3, the greater curvature of the stomach; areas 4–5, lesser curvature; areas 6–8, nodes near the hilus of the spleen, the suprapancreatic, and the infrapancreatic positions, respectively; and area 9, the anterior and posterior pancreaticoduodenal nodes (Table I). The number of nodes isolated from each area and the number showing metastatic involvement are shown in Table II. The maximum number of nodes isolated from any

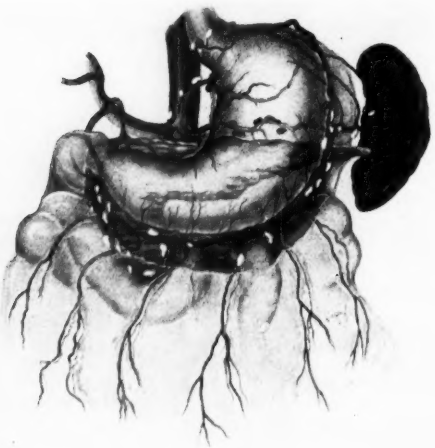


FIG. 3. Case 1. Total gastrectomy, total pancreaticoduodenectomy, and splenectomy. Primary lesion occupied the posterior wall of the upper third of the stomach. Apparent "invasion" of the pancreas was due to inflammatory adhesions. Of 60 nodes isolated from this specimen, 4 had metastatic involvement. Of these, 2 were located along the splenic artery (positive nodes are black), 1 in the left gastric chain and 1 in the celiac axis.

specimen was 78 (Case 2). The minimum number was 37 (Case 4). Case 7, with 68 out of 73 examined nodes (93 per cent) demonstrating metastatic involvement, and Case 2, with 19 of 78 nodes (25 per cent) similarly involved, had the highest percentage of metastases. Both of these primary lesions were highly malignant, undifferentiated cancers. The lowest incidence of involvement was Case 4 in which only 1 of 37 nodes was positive. Nodes of the left gastric chain were most commonly involved. The second most common area of involvement was the suprapancreatic area including nodes along the splenic artery.

A detailed description of the lymph node involvement together with the location and cell type of the primary lesion have been included in the following individual case histories.

CASE REPORTS

CASE 1. L. B., a 56 year old white male, was admitted with a 1 year history of dysphagia, intolerance to solid foods, and a 45 pound weight loss. Physical

TABLE I.—AREA GROUPINGS OF LYMPH NODE DISTRIBUTION USED IN STUDYING THE LYMPHATIC SPREAD OF GASTRIC CANCER

Area 1.	Greater curvature of the stomach from the esophagus to the lowest short gastric artery. Principally included are the parietal group and nodes of the pars cardia.
Area 2.	Greater curvature of the stomach from the lowest short gastric artery to a point 2 inches proximal to the pyloric ring. This area includes the right gastroepiploic group (inferior gastric nodes).
Area 3.	The distal 2 inches of the greater curvature. This area includes the subpyloric (infraduodenaopyloric) and retropyloric (gastroduodenal) nodes.
Area 4.	Lesser curvature of the stomach from the esophagus to a point 2 inches proximal to the pylorus. This area includes all nodes located along the major branches of the left gastric artery as well as nodes about the celiac axis.
Area 5.	The distal 2 inches of the lesser curvature. This area includes the suprapyloric (right gastric nodes) and nodes stripped along the hepatic artery.
Area 6.	Hilus of spleen and tail of pancreas.
Area 7.	Retroperitoneal suprapancreatic area and nodes along the main stem of the splenic artery. Because of large numbers of nodes found in this area in certain specimens it is possible that the vitiation of anatomy produced by large tumor masses has produced an involuntary inclusion of nodes that might otherwise not be so located.
Area 8.	Inferior border of the pancreas proximal to the tail.
Area 9.	Anterior and posterior pancreaticoduodenal nodes.

Although for the most part this is an accurate assessment of lymph node position, obscuration of anatomy produced by large tumor masses precludes complete accuracy.

examination revealed evidence of recent weight loss but was otherwise negative. Laboratory examinations were within normal limits. Upper gastrointestinal roentgenograms revealed an intrinsic neoplasm involving the cardia of the stomach and the terminal esophagus. Biopsies of the lesion (esophagoscopy) taken from the terminal esophagus were positive for adenocarcinoma. The patient was prepared for surgery by high caloric, high protein feedings for 10 days.

Exploration through a combined thoracoabdominal incision revealed no hepatic or distal peritoneal metastases. The lesion involved the upper third of the stomach and had infiltrated along the course of the left gastric artery. It was adherent to the superior border of the pancreas. The omentum and gastrocolic ligament were mobilized from the transverse colon. The diaphragmatic peritoneal attachments of the spleen were divided, and the tail and inferior margin of the pancreas were mobilized after ligation of the inferior mesenteric vein. The jejunum was divided just below the ligament of Treitz and the proximal end closed with a purse-string suture. The gastroduodenal and

TABLE II.—AREA GROUPINGS OF LYMPH NODE INVOLVEMENT SHOWING THE NUMBER OF NODES EXAMINED AND THE NUMBER POSITIVE FOR EACH SPECIMEN

		Lymph node area									
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Totals*
Case 1 L.B.											
	Nodes examined	6	0	10	10	0	3	18	5	8	60
	Nodes positive	0	0	0	2	0	0	2	0	0	4
Case 2 P.K.											
	Nodes examined	0	8	10	17	2	12	12	13	4	78
	Nodes positive	0	3	4	5	2	0	5	0	0	19
Case 3 D.D.											
	Nodes examined	0	5	8	17	0	11	21	3	9	74
	Nodes positive	0	0	0	0	0	3	1	0	0	4
Case 4 H.M.											
	Nodes examined	7	3	8	8	0	3	5	0	3	37
	Nodes positive	0	0	0	1	0	0	0	0	0	1
Case 5 E.B.											
	Nodes examined	3	14	11	14	2	0	18	0	5	67
	Nodes positive	0	0	0	1	2	0	1	0	0	4
Case 6 R.P.											
	Nodes examined	5	7	7	21	6	3	4	3	—	56
	Nodes positive	0	0	0	4	0	0	0	0	—	4
Case 7 V.F.											
	Nodes examined	6	12	5	23	2	3	16	6	—	73
	Nodes positive	6	12	3	23	2	1	16	5	—	68

inferior pancreaticoduodenal arteries were then ligated, the common duct was sectioned, and the duodenum and head of the pancreas were mobilized. This block of tissue was then rotated superiorly to permit ligation of the splenic vein. The gastrohepatic ligament was divided in close proximity to the liver, and the left gastric and splenic arteries were ligated at their origin from the celiac axis. The areolar tissue and nodes along the hepatic artery were then removed. During mobilization of the lower third of the esophagus the right side of the chest cavity was entered through a rent in the pleura because of adherence to the terminal esophagus. This procedure was accompanied by a sharp fall in blood pressure, and the operation was delayed for about 1½ hours while circulatory stability was restored. The esophagus was divided at the junction of the lower and middle thirds, and continuity of the gastrointestinal tract was restored by an end of esophagus to side of jejunum anastomosis, choledochojejunostomy and distal enteroenterostomy. The patient's condition at the end of the operation was satisfactory. Operating time was 7 hours. The amount of blood transfused during operation was 4,000 milliliters.

The postoperative period was satisfactory for the first 12 hours at which time the patient became hypotensive. Whole blood was started but after administration of about 250 milliliters he became markedly dyspneic and cyanotic. Transfusion was discontinued despite continuing hypotention. Bronchoscopic examination revealed no obstruction of major bronchi. A diagnosis of "congestive atelectasis" was made, and positive pressure oxygen therapy was instituted. Deterioration was rapid, and the patient expired 30 hours after operation.

Autopsy revealed the cause of death to be bilateral atelectasis with associated marked congestion and edema of both lungs. There was no evidence of residual cancer.

The lesion was a polypoid fungating mass, 8 centimeters in diameter, involving the posterior wall of the upper one-third of the stomach. Microscopic examination demonstrated a moderately well differentiated adenocarcinoma infiltrating through all layers of the stomach wall. The apparent involvement of the body of the pancreas was due to inflammatory adhesions rather than neoplastic invasion. Both ends were free of cancer. Of 60 nodes isolated from the specimen 4 were positive (Tables I and II and Fig. 3). Two of these were located along the main axis of the splenic artery just above the body of the pancreas, 1 was found along the main stem of the left gastric artery, and 1 involved a celiac node of the preaortic chain.

CASE 2. P. K., a 41 year old white male, was admitted with a 3 month history of epigastric pain and intermittent nausea and vomiting. He had lost 16 pounds in the past month. Physical examination was essentially negative. A roentgenogram of the upper gastrointestinal tract revealed an infiltrating neoplasm of the lesser curvature of the stomach. Laboratory studies were essentially normal. Preparation for operation consisted of a 2 week regimen of augmented oral feeding of a high calorie, high protein diet.

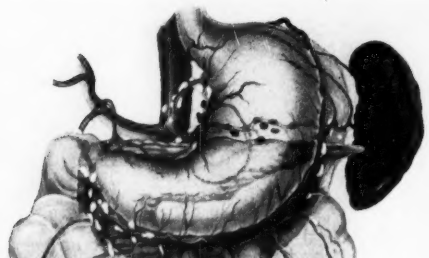


FIG. 4. Case 2. Total gastrectomy, total pancreaticoduodenectomy, and splenectomy. As demonstrated by the outline, the primary lesion occupied the lesser curvature of the stomach and had invaded the pancreas. Microscopically this lesion demonstrated diffuse infiltration and was poorly differentiated. Of 78 nodes isolated, 19 had metastases. Five positive nodes along the splenic artery are demonstrated by dark cross-hatching. Of the remaining, 9 were found in the hepatic chain group, 3 in the left gastric group, and 2 about the celiac axis.

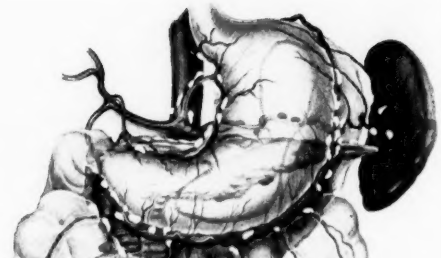


FIG. 5. Case 3. Total gastrectomy, total pancreaticoduodenectomy, and splenectomy. The primary lesion has been outlined on the posterior wall of the stomach of which about 50 per cent was involved. Microscopically this cancer was a moderately well differentiated papilliferous lesion and had invaded the pancreas. Of 74 nodes isolated only 4 were positive. Of these, 3 were found about the hilus of the spleen and the tail of the pancreas. The other was found near the origin of the splenic artery at the celiac axis.

The abdomen was entered through a transverse incision of the upper quadrants. The lesion was found to occupy about 75 per cent of the lesser curvature of the stomach and was adherent to the underlying pancreas. The lymph nodes from drainage areas along the left gastric artery appeared grossly involved as did nodes along the whole of the superior margin of the pancreas. A total gastrectomy, pancreatectomy, duodenectomy, splenectomy, as well as total removal of the omentum, gastrocolic and gastrohepatic ligaments were performed en bloc. The splenic and left gastric arteries were ligated at their origin from the celiac axis. Areolar tissue and nodes along the hepatic artery were stripped separately. Total operating time was 6 hours. Amount of blood transfused during operation was 3,000 milliliters. The operation was well tolerated.

The postoperative course was suprisingly smooth. He was maintained on parenteral fluids and alimentation for the first 5 postoperative days when oral feedings were begun. Caloric intake was gradually increased to 3,000 per day. Blood sugar levels were adequately regulated by daily administration of 18 to 20 units of NPH insulin. He was finally discharged from the hospital on the fortieth postoperative day.

The primary lesion was hard and infiltrating and located on the posterior aspect of the lesser curvature. About 75 per cent of the lesser curvature was involved and the body of the pancreas had been invaded. Microscopic examination demonstrated a diffusely infiltrating, poorly differentiated carcinoma with no glandular pattern. Of 78 nodes isolated from the specimen, 19 were positive. Five positive nodes were located along the splenic artery, 9 involved nodes of the hepatic group (suprapyloric, infrapyloric, and gastroepiploic), 3 nodes of the left gastric group were positive as were 2 about the celiac axis (Tables I and II and Fig. 4).

The patient was seen at 2 weeks and 4 weeks following discharge. During this period he had gained 4 pounds. Eight weeks following discharge he was brought into the hospital in a comatose state. He had continued to take insulin despite a progressive inability to eat during the 10 days prior to admission. An emergency blood sugar revealed it to be only 7 milligrams per cent. Response to treatment for insulin hypoglycemia was prompt. Physical examination revealed marked ascites, and masses thought to be recurrent neoplasm could be palpated through the abdominal wall. Deterioration was rapid and death occurred just 125 days after his operation. Autopsy was not permitted but it was reasonably obvious that death was due to recurrent cancer.

CASE 3. D. D., a 47 year old white male, was admitted giving a 1 year history of epigastric fullness and eructation and a 2 month history of nausea and loss of appetite. He had lost 30 pounds during this time. Phys-

ical examination demonstrated an epigastric mass that did not seem fixed and evidence of recent weight loss but was otherwise negative. Routine laboratory results were within normal limits. Roentgenograms of the upper gastrointestinal tract revealed a large polypoid mass occupying the lower half of the stomach. Preoperative preparation consisted of 8 days of high caloric, high protein diet.

The mass was exposed through a transverse incision of the upper quadrants. The liver was negative for metastatic involvement as were the distal peritoneal surfaces. The lesion occupied the middle third of the stomach, was adherent to the head and body of the pancreas, and there was apparent involvement of the nodes about the celiac axis. After freeing of the omentum and gastrocolic ligament, a total gastrectomy, total pancreatectomy, splenectomy, and duodenectomy were done. The nodes about the celiac axis were totally grossly removed. The operation was well tolerated. Operating time was 5½ hours. The amount of blood transfused during operation was 2,000 milliliters.

This patient lived 23 days following operation. Death was due to progressive inanition as at no time was he able to take adequate oral feedings. The immediate cause of death was severe generalized peritonitis.

Autopsy revealed severe generalized fibrinopurulent peritonitis with multiple intra-abdominal abscesses and severe mycelial infection of both lungs. Residual carcinoma was found in the adventitia of the abdominal aorta. The anastomoses were intact.

Examination of specimen showed a large ulcerated polypoid lesion about 12 by 7 centimeters involving 50 per cent of the posterior wall of the stomach and invading the body and head of the pancreas. At microscopic examination a moderately well differentiated papilliferous adenocarcinoma probably arising in a polyp was noted. The lesion infiltrated through the wall of the stomach. Of 74 nodes examined 4 were positive. All positive nodes were found in the splenic group, 3 being proximate to the hilus of spleen and tail of pancreas, and the other found near the origin of the splenic artery at the celiac axis (Tables I and II and Fig. 5).

CASE 4. H. M., a 57 year old white male, was admitted with a history of having been treated for peptic ulcer for 12 years. His symptoms had been intermittent and had responded periodically to various types of treatment. Two months before admission the pain had recurred and remained constant. He also had observed postprandial fullness and a weight loss of 13 pounds.

Routine physical examination was negative except for evidence of recent weight loss. Laboratory examinations were negative. Roentgenograms of the stomach demonstrated a constant irregularity and filling defect in the midportion of the lesser curvature of the stomach. This lesion was also demonstrated on gastroscopy and was believed to be carcinoma.

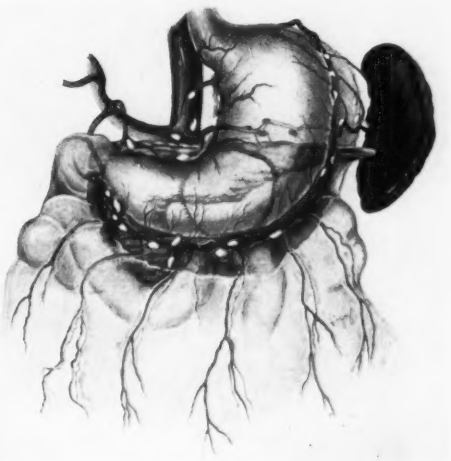


FIG. 6. Case 4. Total gastrectomy, total pancreaticoduodenectomy, and splenectomy. The primary lesion has been outlined. It occupied the posterior wall of the lower and middle thirds of the stomach. Microscopically, it was a papilliferous adenocarcinoma that had invaded through the wall of the stomach and into the pancreas. Only 37 nodes were isolated from this specimen. Despite numerous palpable "involved" nodes at operation, only 1 was positive for metastatic involvement. This was found in the celiac axis.

Preoperative preparation consisted of 10 days of a high caloric, high protein diet. He gained 5 pounds this time. At operation a neoplastic mass was found on the lesser curvature that had apparently invaded the body and distal portion of the head of the pancreas. A total gastrectomy combined with total pancreaticoduodenectomy, splenectomy, omentectomy, and resection of the medial half of the left lobe of the liver was performed. The patient tolerated the operation well. Operating time was 6 hours. Amount of blood transfused was 4.000 milliliters.

The immediate postoperative course was characterized by daily spikes of temperature to 104 degrees F., but his general condition was considered satisfactory. Sudden death occurred 4 days postoperatively. Autopsy revealed the cause to be thrombosis of the anterior descending branch of the left coronary artery. No residual carcinoma was demonstrated.

The primary lesion was a polypoid ulcerating lesion 8 centimeters in diameter involving the posterior wall of the lower and middle thirds of the stomach and apparently invading the body of the pancreas. Numerous hard firm lymph nodes were palpated. Microscopic examination showed a papilliferous adenocarcinoma invading through the wall of the stomach and into the pancreas. Only 37 nodes were isolated, and of these only 1 was positive for cancer. It was found in the celiac axis (Tables I and II and Fig. 6).

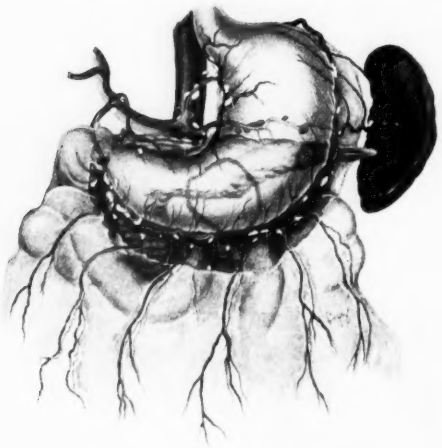


FIG. 7. Case 5. Total pancreatectomy, total pancreaticoduodenectomy, and splenectomy. As outlined, the primary lesion involved the posterior aspect of the lesser curvature and had invaded the pancreas. Microscopically, it was a diffusely infiltrating, poorly differentiated cancer with no glandular pattern. Of 67 lymph nodes isolated, only 4 were positive. Two or 3 were suprapyloric in position, one was found in the celiac axis and the other along the splenic artery near its origin.

CASE 5. E. M., a 50 year old white male, was admitted with a 9 month history of epigastric pain and a weight loss of 25 pounds. Three months previously roentgenograms of the upper gastrointestinal tract revealed a gastric ulcer on the lesser curvature of the stomach. He had been treated conservatively with little response. Physical examination was negative except for evidence of recent weight loss. Routine laboratory examinations were negative. Roentgenograms of the upper gastrointestinal tract revealed a persistent, active gastric ulcer about 2 inches proximal to the pylorus which appeared larger than in previous films. Gastroscopy demonstrated a neoplasm on the lesser curvature. Preparation for operation consisted of 7 days on a high caloric, high protein diet.

Under hypotensive anesthesia, exploration was carried out through a transverse incision of the upper quadrants. The lesion was found as described on x-ray examination and had invaded the head of the pancreas. There were no gross hepatic metastases and no distal peritoneal spread. A total gastrectomy, total pancreaticoduodenectomy, and splenectomy were done with continuity of the gastrointestinal tract restored by an end-to-side esophagojejunostomy, enteroenterostomy, and choledojejunostomy. Operating time was 4½ hours. The amount of blood transfused during operation was 2,000 milliliters.

For the first 3 days the postoperative course was entirely satisfactory. On the fourth postoperative day parenteral feedings of 10 per cent fructose and 5 per cent amino acids were started. After about 1,500 milliliters of this solution had been given intravenously the temperature rose to 107 degrees F., and the patient became comatose. Treatment with adrenocorticotropic hormone and cortisone was instituted with dramatic return of temperature to normal. He failed to continue this improvement however. The patient became septic, progressively comatose, and died on the eighth postoperative day apparently of acute hepatic failure.

At autopsy no residual carcinoma was found. All anastomoses were intact. The liver was filled with small abscesses, and a subacute fibrinopurulent leptomeningitis was also attendant. Cause of death was acute hepatic failure secondary to suppurative hepatic disease.

The primary lesion was an ulcerating mass 6 centimeters in diameter involving the posterior aspect of the lesser curvature and adherent to the head of the pancreas. At miscroscopic examination a diffusely infiltrating poorly differentiated carcinoma with no glandular pattern was noted. Of 67 isolated nodes 4 were positive. These included 2 suprapyloric, 1 in the celiac axis and 1 along the splenic artery near its origin. Fiver retroduodenal nodes were negative (Tables I and II and Fig. 7).

CASE 6. R. P., a 47 year old white female, was admitted with a 10 month history of epigastric pain, nausea, and flatulence. There had been an 8 year history of gastrointestinal symptoms, and about a year prior to admission she had received 5 blood transfusions because of gastric hemorrhage. The blood pressure was elevated to 210/120 without evidence of cardiac decompensation. The remainder of the examination was essentially negative.

Urinalysis revealed a 1 plus albuminuria, 2 to 4 white blood cells per high power field and numerous granular and cellular casts. The hemoglobin was 9.5 grams and the red blood cells 3.2 million. White blood cell count was normal with normal differential. Free acid was present in the fasting gastric aspiration. An electrocardiogram was within normal limits. Roentgenograms revealed a neoplasm involving the upper and middle thirds of the stomach which was confirmed by gastroscopy.

Preparative preparation consisted of administration of 1,500 milliliters of whole blood and 8 days of a high protein, high caloric diet. Operation was performed through a combined thoracoabdominal incision. The lesion was adherent to the middle third of the pancreas. A total gastrectomy combined with splenectomy, subtotal pancreatectomy (80 per cent), excision of the lower third of the esophagus, and omentectomy was performed. Continuity of the gastrointestinal tract was restored by means of a Roux Y type of end-to-end esophagojejunostomy. The operation was well tolerated. Operating time was 5½ hours. Amount of blood transfused was 2,000 mi i-

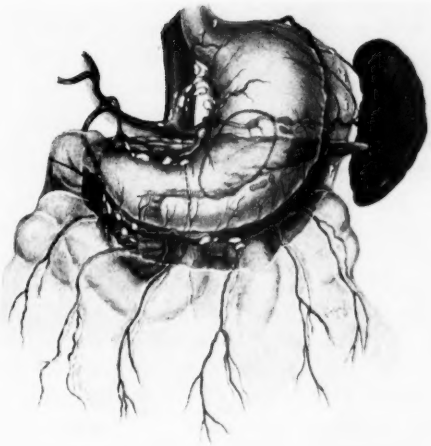


FIG. 8. Case 6. Total gastrectomy, splenectomy, and subtotal pancreatectomy. As outlined, the primary lesion occupied the posterior wall near the lesser curvature of the stomach and had invaded the middle third of the pancreas. Microscopically, it was a moderately well differentiated adenocarcinoma. Of 56 isolated nodes, 4 were positive. All 4 were found in the superior gastric group along the branches of the left gastric artery.

FIG. 9. Case 7. Total gastrectomy, splenectomy, and subtotal pancreatectomy. As outlined, the lesion occupied the posterior wall of the upper third of the stomach and had invaded the pancreas. Microscopically it was an undifferentiated medullary carcinoma widely infiltrating the wall of the stomach. Of 73 isolated nodes, 68 were positive. The dark cross-hatched areas represent retroperitoneal nodes about the branches of the splenic artery.

liters. Convalescence was extremely slow and implementation of oral intake with parenteral fluids was necessary for 19 days. She was discharged on the twenty-eighth postoperative day and was able to tolerate a 6 feeding soft diet.

The patient did not return to the outpatient clinic. Follow-up has revealed that she died from her disease 4 months following discharge. This was confirmed by autopsy.

Examination of specimen showed that the primary lesion was an 8 centimeter ulcerated mass on the posterior wall near the lesser curvature of the stomach and was adherent to the middle third of the pancreas. At microscopic examination a moderately well differentiated adenocarcinoma infiltrating through all layers of the stomach wall and into the pancreas was noted. Of 56 nodes examined 4 were positive. All 4 were found in the superior gastric group along the branches of the left gastric artery (Tables I and II and Fig. 8).

CASE 7. V. F., a 63 year old white female, was admitted giving a 4 month history of nausea and weakness. One episode of hematemesis had occurred and she had lost 10 pounds. Physical examination was essentially negative as were routine laboratory examinations. Barium studies of the stomach demonstrated a large neoplasm occupying the cardia and upper fundus of the stomach. Preparation for operation consisted principally of a 10 day period on a high protein, high caloric diet.

The neoplasm was explored through a combined thoracoabdominal approach. The liver was free of metastases and there was no distal peritoneal spread. There seemed to be extensive lymph node involvement. The lesion was adherent to the body of the pancreas but appeared resectable. A total gastrectomy, splenectomy, and subtotal pancreatectomy (80 per cent) were done. The gastrointestinal tract was reconstructed by carefully isolating a loop of jejunum and using it to bridge the defect between the esophagus and duodenum. Operating time was 4½ hours. The amount of blood transfused during operation was 1,500 millimeters. The operation was well tolerated.

For the first 7 postoperative days the patient's condition was good. She became progressively febrile, and a barium swallow on the tenth postoperative day revealed a small leak at the anastomosis between the esophagus and jejunum. A left subdiaphragmatic abscess was drained, but the patient's condition rapidly deteriorated, and she expired on the twelfth postoperative day. At autopsy there was no evidence of residual carcinoma. The loop of jejunum which had been used as a "stomach" between the esophagus and duodenum was infarcted for a distance of about an inch just below the esophagus. This had resulted in an anastomotic leak. The cause of death was severe generalized fibrinopurulent peritonitis.

Examination of specimen showed a large mass with a central ulcerated area of 8 centimeters occupying

the posterior wall of the upper third of the stomach and involving the pancreas. Microscopic examination demonstrated an undifferentiated medullary carcinoma widely infiltrating the wall of the stomach. Of 73 isolated nodes, 68 were positive. The only nodes not involved were 2 in the subpyloric group, 2 in the hilus of the spleen, and 1 along the inferior margin of the pancreas (Tables I and II and Fig. 9).

DISCUSSION

Nothing of statistical value can be obtained from this small group of cases. Certain observations may be of interest, however.

Predictability of lymph node spread of cancer of the stomach based upon the location of the primary lesion is highly unreliable although some tendency to follow intramural drainage patterns was observed (Fig. 1). Despite the advanced state of these cancers only 2 demonstrated extensive node involvement (Cases 2 and 7). The remainder had 4 or less involved nodes. Nodes thought to be "positive" at operation because of increased firmness and size were often negative. This method of determining the degree of nodal metastatic involvement is unreliable.

A deliberate attempt to remove all lymph nodes about the celiac axis was facilitated by the extensive dissection. Every specimen but 1 had involvement of nodes that were thought to be in the celiac group. It is conceivable that these nodes may have been proximal members of the left gastric or splenic chain nodes. In Case 4 the only positive node found in 37 examined was in the celiac axis. It would appear, therefore, that a detailed excision of nodes about the celiac axis should be an integral part of operations for cancer of the stomach when a "cure" seems possible.

Splenic group nodes revealed metastatic involvement in 5 of 7 specimens. In the 2 specimens not demonstrating such involvement, the lesions were close to the lesser curvature and were histologically moderately well differentiated adenocarcinomas. In 4 of 5 specimens with splenic chain involvement, these nodes could be removed only by ligating the splenic artery at its origin from the celiac axis and removing it completely with the accompanying suprapancreatic nodes. Splenectomy combined with simple amputation of the tail of the pancreas and ligation of the splenic artery near the hilus of the spleen would not have accomplished removal of these nodes. Extirpation of nodes accompanying the splenic artery can be facilitated by excision of at least 70 per cent of the pancreas leaving only that portion in intimate contact with the duodenal loop. The study of these specimens would seem to confirm previous work by Sunderland and associates demonstrating a greater tendency of cancers in the upper half of the stomach and those of a more undifferentiated type to spread to the splenic node group.

Excision of the total pancreas and duodenum in 5 specimens permitted examination of the anterior and posterior pancreaticoduodenal nodes. There was no involvement in any specimen. It would appear, therefore, that involvement of these nodes would represent an extensive involvement of the duodenum or a reversal of lymph flow due to blockage of more direct channels. Operative procedure directed at their specific removal would have questionable value as their involvement would be an end product of an extensive and widespread metastatic involvement.

Removal of the head of the pancreas in order to facilitate a more radical excision of the hepatic chain nodes about the pylorus of the stomach has been done by Mayo and associates for antral carcinomas (3). The mortality of the operation has been high and the incidence of "cure" low. Whether or not such procedure is justified as part of the operative excision of certain cancers of the stomach remains to be determined.

These operations were done under circumstances in which the lesion appeared "hopeless" without removal of all or part of the pancreas. Although the removed specimens have permitted a study of practically all of the known immediate areas of

lymphatic spread of cancer of the stomach, not a single patient was benefited by these procedures. The immediate hospital mortality was a prohibitive 72 per cent. Of the 2 patients who left the hospital following their operation, one was dead in 3 months and the other in less than 5 months, both from recurrence of the cancer.

The traumatic and metabolic insult produced by total gastrectomy combined with total pancreaticoduodenectomy is of great magnitude and yet is not incompatible with life as witnessed by patient P. K. (Case 2). After temporary improvement he rapidly succumbed to massive recurrence 3 months after operation. This limited experience with 5 cases, however, has strongly suggested that the operation of total gastrectomy combined with total pancreaticoduodenectomy has little to offer the patient with gastric cancer. The advanced state of the neoplastic process necessitating such operation, the metabolic insult that enhances the potential for serious and lethal postoperative complications, and the possible biologic nature of the neoplastic cell attending invasive cancers preclude obtainment of acceptable results.

SUMMARY

1. Detailed studies of the lymphatic spread of advanced cancer of the stomach have been carried out in 5 specimens consisting of total gastrectomy, total pancreaticoduodenectomy, and splenectomy. Two other specimens were studied that included removal of 80 per cent of the pancreas but the duodenum was left intact.

2. Specimens contained from 37 to 78 nodes. The highest incidence of metastatic involvement was 68 of 73 nodes. The lowest was 1 positive node of 37 so isolated. The 2 most undifferentiated tumors had the highest incidence of lymph node involvement.

3. Five of 7 specimens demonstrated involvement of the splenic chain nodes. Ligation of the splenic artery at its origin from the celiax axis and complete removal with attendant nodes and connective tissue was necessary in 4 of 5 specimens if these nodes were to be adequately removed. Careful excision of "celiac axis" nodes has been emphasized because of involvement in 6 of 7 specimens.

4. Examination of the anterior and posterior pancreaticoduodenal nodes in 5 specimens demonstrated no involvement. Excision of the head of the pancreas in order to remove only these nodes does not appear worth while.

5. Little clinical benefit attended these operations. The hospital mortality was 72 per cent. Of 2 patients leaving the hospital death occurred 3 and 5 months after operation from recurrence of the cancer.

6. The operation of total gastrectomy combined with total pancreaticoduodenectomy is not a satisfactory procedure for cancer of the stomach.

REFERENCES

1. COLLER, F. A., KAY, E. B., and MCINTYRE, R. S. Regional lymphatic metastases of carcinoma of the stomach. Arch. Surg., 1941, 43: 748.
2. MAYO, C. Cancer of the stomach and its surgical treatment. Ann. Surg., 1919, 70: 236.
3. MAYO, H. W., JR., OWENS, J. K., and WEINBERG, M. A critical evaluation of radical subtotal gastric resection as a definite procedure for antral gastric carcinoma. Ann. Surg., 1955, 141: 830. Quoting Harvey, H. D. Personal communication, 1954.
4. PACK, G. T. End results in the treatment of cancer of the stomach. Surgery, 1948, 24: 769–778.
5. ROUVIÈRE, H. Anatomy of the Human Lymphatic System. Pp. 183–205. Ann Arbor, Mich. Edwards Brothers, Inc., 1938.
6. SUNDERLAND, D. A., NCNEER, G., ORTEGA, L. G., and PEARCE, L. S. The lymphatic spread of gastric cancer. Cancer, 1953, 6: 987.

LEIOMYOSARCOMA OF THE JEJUNUM

HARVEY J. RASZKOWSKI, M.D., F.A.C.S., and
KURT H. KENT, M.D., Lynwood, California

THE DIAGNOSIS of a malignant tumor of the jejunum is not usually made in the initial stages for two reasons: first, such lesions are infrequent; and second, the symptomatology is nonspecific, being similar to that of the more common diseases of the gastrointestinal tract.

In June 1955 Horsley and Means collected 110 known cases of leiomyosarcoma of the small bowel including 2 of their own. In 95 instances in which the site was specified, 38 occurred in the jejunum, 33 in the duodenum, and 24 in the ileum. Subsequently Martin described 3 more cases, 2 of which were in the jejunum. We wish to report 3 additional leiomyosarcomas of the jejunum that were seen at the St. Francis Hospital within a period of 1 year. This is rather unique, for one is impressed with the rarity of the lesion by noting that in Mayo's review of 108 small bowel lesions during the period from 1907 to 1939, only 2 were leiomyosarcomas of the jejunum. However, a later review from the Mayo Clinic by Starr and Dockerty for the period from 1912 through 1952 established a total of 19 jejunal leiomyosarcomas. Rosenfeld and Brinkman found 11 proved cases of neoplasm in the small bowel (2 leiomyosarcomas) among 65,638 surgical admissions to Kings County Hospital in an 11 year interval from 1940 to 1951. At St. Francis Hospital during a 10 year period, 1945 to 1955, 26 small intestinal tumors (3 leiomyosarcomas) were encountered among 22,200 major surgical procedures. We will endeavor to emphasize the surgical as well as the radiologic features of this tumor of the small bowel.

From the Departments of Surgery and Radiology, St. Francis Hospital, Lynwood, California.

CASE 1. S. V. H., a white male, 40 years of age, was admitted to the hospital on March 24, 1955. He stated that 1 year previously he began to notice pain and dull discomfort in left side of abdomen. Pain had gradually become persistent, and in the past 2 months it had become severe. With the onset of his illness he had passed tarry stools and was treated for anemia. An upper gastrointestinal series taken at that time, in another hospital, was reported as normal. Night sweats and fever had been present off and on for 6 to 8 months. He had noticed exhaustion and weakness and had lost 7 pounds in weight during the past 2 months. There had been a loss of appetite with nausea, but he had experienced no vomiting.

Examination revealed an acutely ill patient. There was a large, palpable mass in the left upper quadrant of the abdomen which was difficult to outline because of tenderness. The liver was not palpable, and the rectal shelf was soft and contained no nodules. The axillary lymph nodes and the left epitrochlear nodes were enlarged. Temperature was 99 degrees, and pulse was 80.

The laboratory data were as follows: hemoglobin 13.4 grams; white blood count 10,300 with a normal differential count; sedimentation rate, 23 millimeters in 1 hour; and blood chemistry determinations and blood Wassermann revealed no abnormalities. An electrocardiogram and roentgenologic examinations of the chest, gallbladder, and colon showed no abnormality. An upper gastrointestinal series was performed on March 25, 1955, and the following report was made: "Large lesion in the proximal jejunum below the ligament of Treitz, most likely neoplasm, lymphosarcoma especially to be considered. Mass is fixed and closely applied to the stomach. Fistulous communication not entirely ruled out" (Fig. 1).

At operation on March 29, 1955 a large, nodular, yellowish-grey tumor was encountered in the region of the ligament of Treitz. The mass was approximately 12 centimeters in diameter, and the inferior portion was entirely retroperitoneal. The upper portion of the jejunum over the tumor was thinned out, and its mesentery contained several enlarged lymph nodes, but there was no other evidence of possible spread. The liver was not enlarged, nor could any nodules be palpated within its substance. The retroperitoneal portion of the tumor, together with a segment of jejunum and its mesentery, was removed, and an end-to-end anastomosis was established between the d

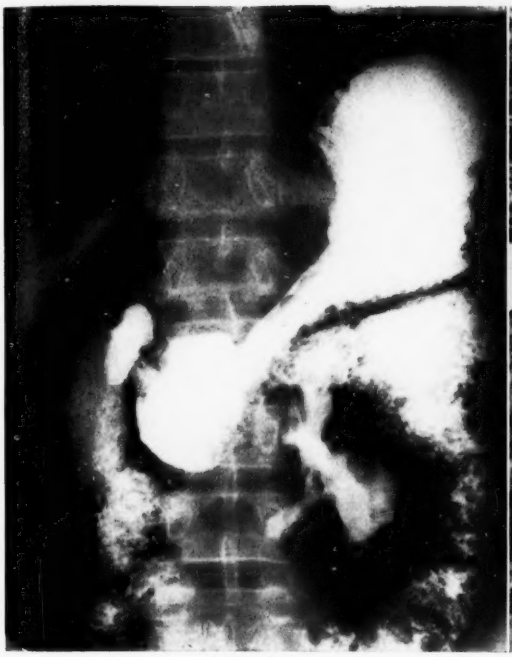


FIG. 1.

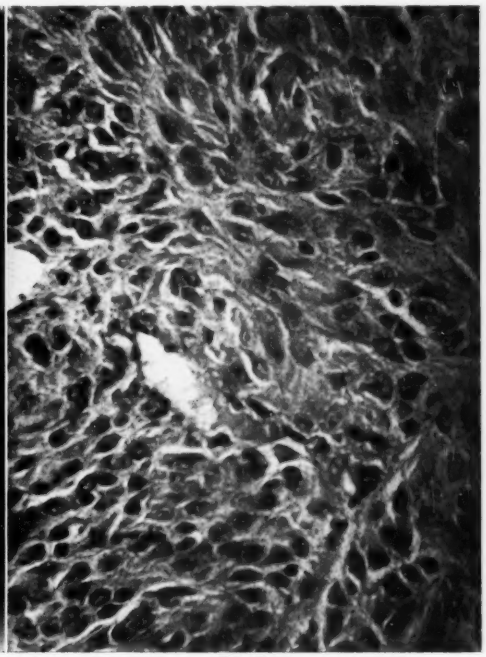


FIG. 2.

FIG. 1. Case 1. Extensive irregular ulceration in the proximal jejunum just below the ligament of Treitz. Note complete obliteration of normal feathery mucosal pattern.
FIG. 2. Case 1. Photomicrograph of tumor showing cellular pleomorphism and mitoses. ×285.

vided ends of jejunum just below the ligament of Treitz.

The specimen consisted of a portion of jejunum 35 centimeters in length with its attached mesentery. A tumor 11 centimeters in diameter was fixed to the mesenteric border and was partially covered by peritoneum. The tumor had produced a 5 centimeter ulceration through the mesenteric border of the bowel wall. Many areas of the neoplasm were composed of necrotic hemorrhagic cysts.

Microscopically the tumor showed a highly cellular structure with the cells tending to be spindle shaped with large rounded or ovoid nuclei. Only a moderate amount of pink staining cytoplasm was present. The cells tended to be arranged in parallel bundles with the formation of an interlacing pattern. Mitotic figures were moderately numerous (Fig. 2). The lymph node sections showed no evidence of metastases. The pathologic diagnosis was leiomyosarcoma of the jejunum.

The patient gained weight and felt very well for 7 months after which he again developed abdominal pain, loss of appetite, and nausea. A mass could be palpated deep in the old abdominal scar. The abdomen was explored, and numerous tumor nodules were present throughout the peritoneum and omentum. The liver was enlarged and nodular. Nodules from the scar and the omentum were removed, both of which showed tumor.

The patient expired 1 month later in hepatic coma. Postmortem examination revealed extensive intra-abdominal metastases involving the liver, omentum, mesentery, and retroperitoneal lymph nodes.

CASE 2. W. E. C. was a 38 year old white male who was first seen on March 25, 1955 with a history of left lower quadrant pain of 10 days' duration. The pain was noticed only with pressure over his abdomen and was aggravated by raising his left leg. During the past 3 months he had had increasing constipation with occasional bouts of diarrhea. There had been no melena, but the stools were smaller in caliber than usual. He attributed fatigue to overwork. His weight had remained constant.

The patient did not appear ill. On examination there was a slightly tender mass, 5 by 4 by 3 centimeters, in the left lower quadrant. The rectal shelf was free from peritoneal implants. The sigmoidoscope was passed 22 centimeters, and no abnormality was found in the rectum or lower sigmoid.

The hemoglobin was 14.7 grams, the white blood cells 8,700. The urinalysis was normal. A barium enema on March 28, 1955 and an intravenous pyelogram on March 30, 1955 revealed no abnormal find-

FIG. 3.

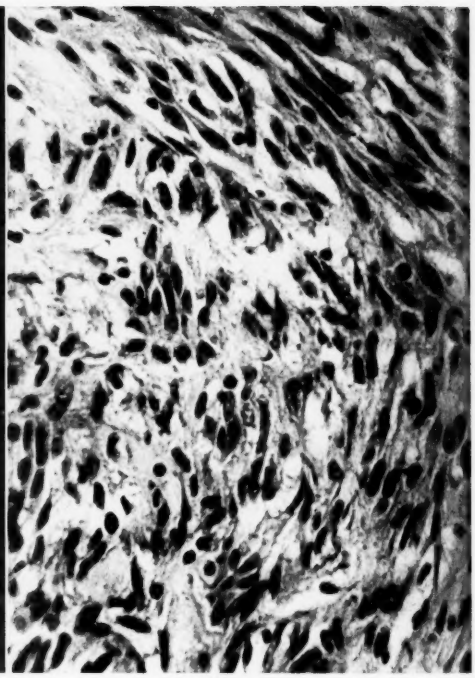


FIG. 4.

FIG. 3. Case 2. Loop of jejunum located to the left of the lower lumbar spine showing rigidity of the lateral wall, simulating a large inverted 3, caused by extraluminal tumor infiltration. The mucosal pattern is preserved.

FIG. 4. Case 2. Photomicrograph of tumor in jejunal wall. ×275.

ings. The roentgenologist made the following report on an upper gastrointestinal series done on March 31, 1955: "No evidence of pathology in the upper gastrointestinal tract. Probable extrinsic pressure defect on the proximal ileum by a clinically palpable mass" (Fig. 3).

The patient was seen every 10 to 14 days after this study, but the mass that was first detected was never again palpable. His pain had disappeared. Because it was felt clinically that he had a lesion in the sigmoid when first seen, another barium enema was ordered on May 31, 1955, but without any significant findings.

On July 2, 1955 he was seen as an emergency with the following history: He awakened early that morning with pain in the left lower quadrant of his abdomen. The pain was intermittent and had increased in intensity. It was accompanied by chills and fever. He felt nauseated but did not vomit.

Examination at this time revealed an acutely ill patient. The abdomen was diffusely tender, but there was marked rebound tenderness in the left lower quadrant with rigidity. Peristalsis was hypoactive. Rectal examination revealed no masses or tenderness. The pulse was 88 and the temperature was 98.8 degrees.

The laboratory data were as follows: hemoglobin, 16.8 grams; white cell count 17,200 with 79 per cent neutrophiles with 2 band cells. Urinalysis was normal.

The patient was prepared for immediate surgery. At operation a large mass 7 centimeters in diameter was found in the left lower quadrant and was surrounded by adherent omentum. The omentum was amputated and the mass was freed from its loose attachment to the sigmoid colon. The lesion appeared to arise from the wall of the midjejunum and extended into the adjacent mesentery. Numerous enlarged lymph nodes were present in the mesentery of the jejunum and the preaortic lymph nodes were enlarged. There were 2 implants of tumor on the mesentery of ileum, one approximately 1 centimeter in diameter, the other about 2 centimeters in diameter. The liver appeared to be free of demonstrable metastasis. The implants, the tumor, and a segment of jejunum together with its mesentery, were resected. The continuity of the bowel was re-established by means of an end-to-end anastomosis.

The specimen consisted of a 60 centimeter segment of jejunum with its attached mesentery. In its central portion there was a 7 centimeter tumor mass which

FIG. 5.

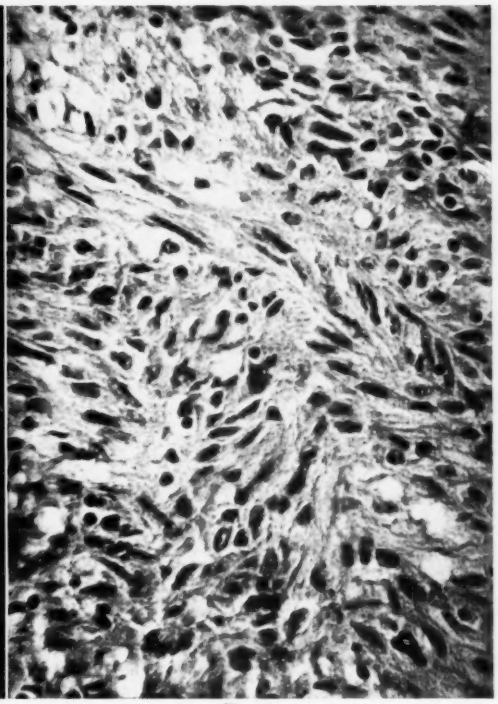


FIG. 6.

FIG. 5. Case 3. Large, well circumscribed tumor in the left mid abdomen, 11 by 11 centimeters in size. Extraluminal growth with infiltrative mucosal defect in the proximal jejunum, about 5 millimeters wide and 7 millimeters long (see arrow).

FIG. 6. Case 3. Photomicrograph of smooth muscle tumor. ×285.

involved the adjacent mesentery. The tumor had formed a 4 centimeter ulceration in the bowel wall and had also perforated the peritoneal surface on the mesenteric side. The specimen was covered in areas with a fibrinopurulent exudate. There were numerous enlarged lymph nodes within the mesentery.

Microscopically the tumor was characterized by bundles of long, smooth muscle cells having moderately large round ended nuclei. In some areas the nuclei tended to be large and irregular in size, and there were occasional mitotic figures (Fig. 4). The peritoneal implants revealed the same microscopic picture. There was no evidence of metastatic tumor in the sections made of the enlarged lymph nodes. The pathologic diagnosis was: (1) leiomyosarcoma of the jejunum with ulceration into the lumen of the bowel and perforation through the mesentery, (2) peritoneal implantation of tumor, (3) acute fibrinopurulent peritonitis.

The patient made a satisfactory recovery and because of implantation of the tumor on distant peritoneal surfaces, he was given a course of x-ray therapy. The dosage was as follows: 1800 roentgens in air to anterior and posterior abdominal fields, 20 by 20 centimeters in size, plus a left lateral field, 10 by 20 centimeters in size, given over a period of 5 weeks (H.V.L. 2.05). He has remained well to date.

CASE 3. (Patient of L. A. Van Hale, M.D.) K. G. M., 64 year old white male, was admitted to the hospital on March 12, 1954 with a history of vague abdominal distress of 30 years' duration. There was a palpable mass in the left upper quadrant, 8 by 15 centimeters in size, which at first was thought to represent an enlarged spleen, possibly due to leukemia. X-ray examination of the upper gastrointestinal tract confirmed the soft tissue mass in the left side of the abdomen at the approximate level of the second and third lumbar vertebrae, about 10 centimeters in diameter, displacing several loops of small bowel. Just below the ligament of Treitz there was a localized distortion of the normal mucosa involving a segment of bowel 7 millimeters long (Fig. 5). From this it appeared that the tumor either arose in the jejunum or secondarily had invaded it. By means of barium enema and intravenous pyelograms, the spleen, kidneys, and colon were excluded from being grossly involved by the mass. A roentgenogram of the chest showed pul-

monary emphysema and an electrocardiogram was essentially normal. The blood count showed a hemoglobin of 14.8 grams and a red blood count of 4,400,000. The initial white blood count of 17,600 decreased to 12,600 two days later. Urinalysis revealed 15 to 20 red blood cells per high power field.

At operation there was an irregular, multicolored, firm, cystic appearing mass in the left upper quadrant which apparently arose either from the mesentery of the small intestine or from the pancreas. The first portion of the jejunum directly at the ligament of Treitz was deeply incorporated in the superior pole of the mass. The tumor was freely movable, and there were no metastases. The remainder of the abdominal contents was normal. Since the jejunum was firmly united with the growth and apparently could not be freed from its attachment, it was resected between two Kocher clamps. It was then freed superiorly by sharp dissection down to the mesentery. The tumor was completely excised. The continuity of the jejunum was then re-established by an anastomosis between the distal and proximal portions.

The specimen was a cystic tumor 10 centimeters in diameter covered externally in most areas by a capsule. A segment of small bowel 10 centimeters in length was fused to the tumor with its peritoneal surface continuous with the tumor capsule. Tumor involved the bowel wall. The tumor tissue was moderately firm, friable, and pale grey. There was a large central cavity lined with shaggy blood clot and necrotic tumor tissue.

Microscopically the tumor was characterized by moderately well differentiated smooth muscle cells with some arrangement in interlacing bundles. The nuclei showed considerable variation in size and shape with occasional large bizarre forms. Nucleoli tended to be prominent. There was a rare mitotic figure. The pathologic diagnosis was leiomyosarcoma of the jejunum with central necrosis (Fig. 6).

The patient was discharged from the hospital in good condition 3 weeks after entry. He returned in January 1955 for removal of a transitional cell carcinoma of the bladder. He was readmitted in November 1955 complaining mainly of weakness and loss of weight. There were no demonstrable metastases. A repeat examination of the upper gastrointestinal tract failed to show any abnormalities. The patient was discharged with the diagnosis of pulmonary emphysema and cor pulmonale.

DISCUSSION

Since the early recognition of small bowel cancer would improve surgical results it is essential that both the surgeon and the radiologist are "small bowel conscious" as Bockus has stated. Clinically the presence of a tumor of the small intestine is usually manifested by one or more of a few rather constant signs and symptoms: (1) pain, (2) hemorrhage, (3) a palpable mass, (4) perforation of the tumor with peritonitis, (5) intestinal obstruction, and (6) intussusception.

There is nothing peculiar in the behavior of leiomyosarcoma of the small bowel that cannot be simulated by other tumors in the same location. Horsley and Mean's review of the literature of leiomyosarcoma of the small intestine indicates that bleeding occurred in approximately two-thirds of the cases. A palpable tumor was observed in over one-half of the cases, while both intestinal obstruction and rupture of the tumor with peritonitis took place in about one-fifth of the cases reported. Intussusception was present in about one-twelfth of their patients. With symptoms of peritonitis, a persistent mass, intestinal obstruction, or intussusception the surgical indications are clearly defined, and there is no reason to delay operation. The most common presenting symptom, however, is bleeding from the tumor. In such instances the site of the bleeding is often obscure, and frequently there is a long interval from the time the patient is first seen until attention is focused on the small bowel or becomes obvious in that location. This delay is well illustrated in Case 1 in which a period of 1 year elapsed from the time of the initial hemorrhage until surgery. Another source of error in the early recognition of these neoplasms can be attributed to the length and mobility of the mesentery of the small intestine. A tumor that can be palpated on one occasion may shift so that it may escape detection on subsequent examinations as illustrated by Case 2. In spite of careful periodic examinations, this growth was discovered only on one occasion during the 4 months before it perforated with resultant peritonitis. These 2 cases emphasize the need of early diagnosis.

The 3 patients whose histories are presented had palpable tumors and abdominal pain. In addition 1 had a severe hemorrhage while another had a perforation of the tumor with peritonitis. The cellularity of these tu-

mors with central necrosis and cyst and cavity formation accounts for the high incidence of ulceration through the mucosa with hemorrhage, as well as the high incidence of its rupture through the serosa, resulting in fistula formation and subsequent peritonitis. Intestinal obstruction and intussusception are less frequently encountered symptoms but at times are the only indication to suggest the possibility of a leiomyosarcoma.

The transition between leiomyomas and leiomyosarcomas is often difficult to assess. Some of these tumors originally are called leiomyomas but subsequently metastasize. At operation the only metastasis found in these 3 cases was in Case 2 occurring in the form of peritoneal implants. The lymphogenous route of dissemination of leiomyosarcoma has been questioned. Horsley and Means in their review of the literature found only 4 cases in which lymph nodes were invaded by tumor. None of our resected surgical specimens showed lymph node metastases. As illustrated by the autopsy findings in Case 1, however, this type of tumor spread does occur and can be one of the late manifestations of the disease.

Weber and Kirklin, in discussing tumors of the small intestine in 1942, stated that x-ray examination of the small bowel had a real contribution to make in the diagnosis of these lesions. It was true then as it still is today that the small bowel investigation is a cumbersome method of examination and does not attain the accuracy of the upper gastrointestinal or colon studies. Therefore, they accepted a general conclusion such as "obstructing, annular or ulcerating lesion." The final diagnosis of leiomyosarcoma rests with the pathologist, but its possibility should be suggested in all intraluminal, intramural, and extraluminal filling defects that involve a limited and short segment of small intestine with either obliteration of the mucosal pattern or ulceration. Additional x-ray findings may include the presence of a mass, or the demonstration of bowel obstruction, or fistula formation. Generally the localized deformity is sharply demarcated at both ends. In inflammatory lesions the affected segment is usually longer. The knowledge that a clinically palpable tumor exists is extremely helpful in guiding the radiologist in his search for the location of the lesion and will enhance his chances of correctly interpreting borderline changes that might have been otherwise easily overlooked. We are referring to Case 2 in which only on the 2½ hour film an evanescent extrinsic pressure defect was seen and correlated with the clinical findings. Others have stated that the roentgen examination is of no help or unsatisfactory, but we contest these opinions by stating that some alteration of the mucosa usually can be found by carefully conducted small bowel studies which consist of serial films at regular intervals with or without spot films until the barium has reached the cecum. Other obstructing or nonobstructing inflammatory, benign, or malignant lesions must be considered in the differential diagnosis.

The 3 cases presented show distinct radiologic findings. There is mucosal involvement in 2, consisting of extensive ulceration in Case 1 and a marked obliteration of the mucosal pattern with a large and well defined extrinsic tumor in Case 3. In Case 2 an extrinsic pressure defect could be identified. The definite value of the routine small bowel examination is thus again affirmed.

Regarding x-ray therapy in the treatment of leiomyosarcoma of the small intestine, little can be found in the literature. A specific article dealing with the radiosensitivity of this lesion was written in 1941 by Chont. He reported what he believed was the first case treated by roentgen irradiation. He was very conservative in his dosage, administering 1,000 roentgens per field to be followed by 600 roentgens 6 weeks later. He stated that leiomyosarcoma is radiosensitive, and that postoperative irradiation should be given routinely in every case even when visible metastases are not found and in inoperable cases for palliation. Similar views have been expressed by Fleming and Pearson. Starr and Dockerty found no benefit from x-ray therapy in their series of 10 cancers treated. How-

ever, details were not given. Of the 3 cases reported in this series, only the patient in Case 2 received postoperative irradiation because he had peritoneal implants at surgery. At the present time, 1 year after completion of therapy, he is living and well. X-ray treatments were not given in Case 3 because the tumor was well differentiated. The absence of visible metastases in Case 1 was believed to make x-ray therapy unnecessary; however, this patient expired 8 months after surgery with extensive tumor dissemination. This experience prompted us to advocate the routine use of postoperative irradiation in the more anaplastic lesions. We thus concur with the opinion expressed by Chont, but we would be more aggressive by administering higher doses.

SUMMARY AND CONCLUSIONS

1. Three cases of leiomyosarcoma of the jejunum are reported, bringing the known total in the recorded literature to 60.

2. When the tumor is palpable or has resulted in intestinal obstruction, intussusception, or peritonitis, the indications for surgery are obvious. With gastrointestinal bleeding as the presenting symptom the early diagnosis can be made only by adequate small bowel x-ray studies.

3. Roentgenologic evidence of disease consists of a localized defect with mucosal obliteration or ulceration and occasional delineation of a mass.

4. Wide resection of the tumor is recommended followed by aggressive x-ray therapy for curative or palliative purposes.

5. Lymph node metastasis is rare but may occur as a late manifestation of the disease.

REFERENCES

1. Bockus, H. L. Gastro-enterology. Vol. II. P. 124. Philadelphia: W. B. Saunders Co., 1944.
2. Chont, L. K. Sarcomas of the small intestine and reference to their radiosensitivity. Radiology, 1941, 36: 86.
3. Fleming, R. M., and Pearson, J. R. Leiomyosarcoma of jejunum. J. Internat. Coll. Surgeons, 1950, 14: 547.
4. Horsley, G. W., and Means, R. L. Leiomyosarcoma of the jejunum, with 2 case reports and a review of the literature. Ann. Surg., 1955, 141: 799.
5. Martin, J. F. Leiomyosarcoma of the small intestine. Am. J. Roentg., 1955, 74: 1081.
6. Mayo, C. W. Malignancy of the small intestine. West. J. Surg., 1940, 48: 403.
7. Rosenfeld, H., and Brinkman, J. Neoplasms of the small bowel. Am. J. Surg., 1953, 85: 691.
8. Starr, G. F., and Dockerty, M. B. Leiomyomas and leiomyosarcomas of the small intestine. Cancer, 1955, 8: 101.
9. Weber, H. M., and Kirklin, B. R. Tumors of the small intestine. Am. J. Roentg., 1942, 47: 243.

A STUDY OF BLADDER FUNCTION FOLLOWING VAGINAL HYSTERECTOMY

J. E. BOWERS, M.D., C. W. MOECKEL, M.D., F.A.C.S., G. L. YATES, M.D., F.A.C.S., and H. R. WESSON, M.D., F.A.C.S., Montclair, New Jersey

THE PURPOSE of this investigation was: (1) to examine by means of cystoscopic, roentgenographic, and manometric methods, preoperatively and postoperatively, the disturbances of bladder function brought about by vaginal hysterectomy with anterior and posterior repair (hereinafter referred to as "vaginal hysterectomy"); and (2) to analyze a series of 200 vaginal hysterectomies; in 100 of these cases routine indwelling urethral catheter drainage had been carried out postoperatively, and in the remainder diversion of the urinary stream by means of trocar cystotomy had been performed in the operating room.

Bladder function studies in obstetric and gynecologic conditions have been carried out almost exclusively by European workers. Bertini studied the vesical tone in pregnancy, noting that a hypotonic bladder in the third trimester returned to normal tone by the twentieth postpartum day. Halber and Richter found increased bladder tone with decreased capacity in 12 females who had undergone radical Wertheim operations. Oehlert made cystometric studies in 21 patients treated by radical Wertheim operations and noted bladder spasticity in 15 cases. Residual urine averaged 132 cubic centimeters. In 4 cases without bladder spasticity there was no residual urine. He concluded that sphincter spasm was of importance in postoperative retention in his series.

Quaini made a single cystometrogram in 29 cases after simple vaginal hysterectomy and in 28 after a vaginal plastic operation and concluded that vesical hypotonia was more common in the latter group, probably because of injury to bladder nerves in dissecting the anterior vaginal wall. Quaini also made preoperative and postoperative cystoscopic examinations in the same group and concluded that the changes were not significant. In another series, intravenous pyelograms and barium enemas were performed after vaginal hysterectomy, and no special pathologic picture was observed.

Methods of circumventing postoperative bladder dysfunction following vaginal hysterectomy have been suggested by various surgeons in this country.

Falk and Bunkin reported on a series of 253 patients treated by vaginal hysterectomy and repair. Urinary retention persisted for an average of 8 days; these authors recommended intermittent catheterization. Gray noted that delay in establishing bladder function was one of the most annoying complications of vaginal hysterectomy; his patients were dicharged with an indwelling catheter to be removed at home. He found that all patients voided on removal of the catheter. Allen and Peterson reported on 2,280 patients with an average age of 49 years; these surgeons used a tidal, closed bladder drainage system postoperatively. Counseller and Hunt varied the extent of urethral repair to suit the preoperative complaints regarding continence of urine, but they noted that most of their patients had prolonged periods of retention following surgery. In 120 vaginal hysterectomies Banks and Rutherford found that no patient had a residual of more than 45 cubic centimeters by the tenth day.

METHOD OF STUDY

In an attempt to correlate data derived from European and American studies on the subject of bladder dysfunction following

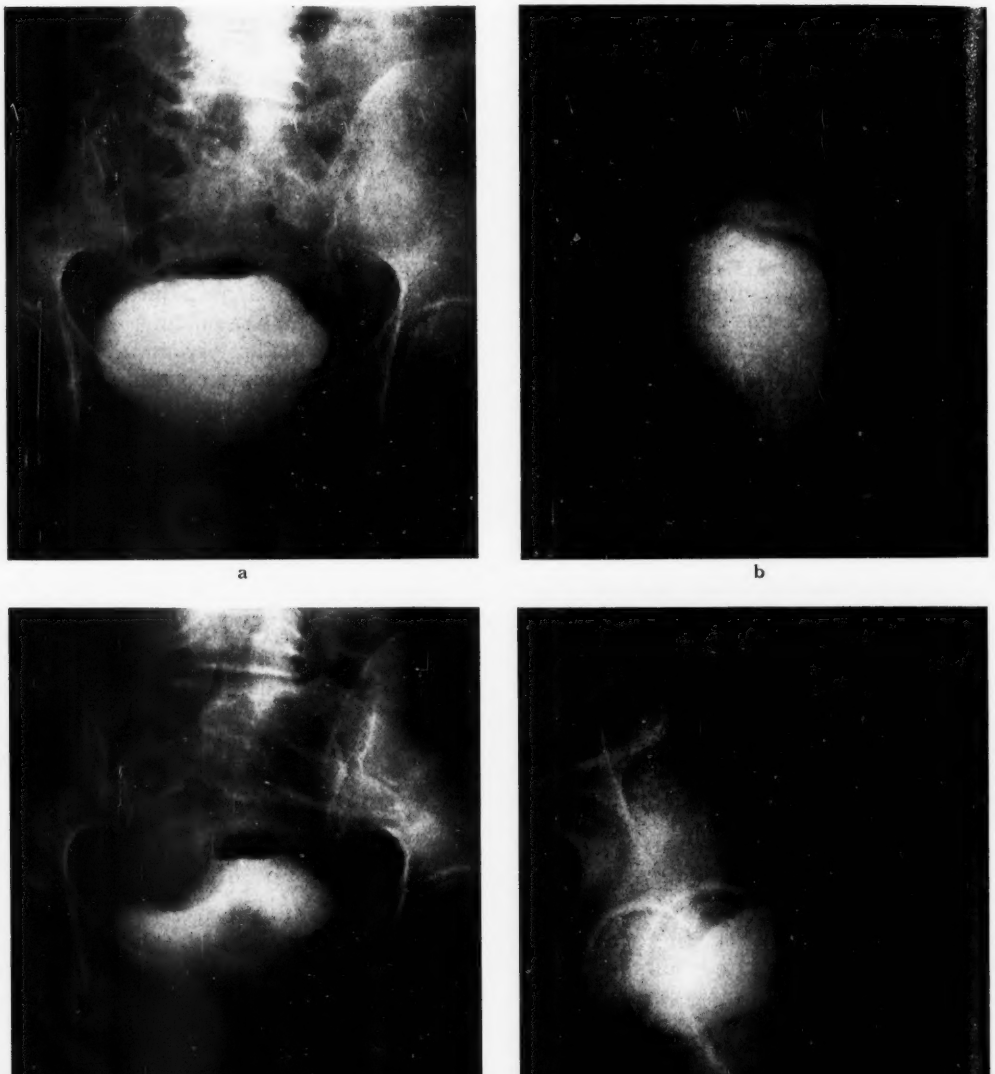


FIG. 1. Patient C. R. (trocar cystotomy). a, b, Preoperative cystograms; c, d, postoperative. Note absence of funnelling of bladder neck in postoperative films.

vaginal hysterectomy, cystoscopic, cystographic, and manometric studies were performed in 15 patients treated by vaginal hysterectomy and repair. The cases were unselected except that, in 8, postoperative urethral catheter drainage was carried out and, in 7, postoperative trocar cystotomy drainage. The following procedures were

carried out on each patient: cystoscopy and panendoscopy, preoperatively and 6 weeks postoperatively; cystography, preoperatively and on discharge from the hospital postoperatively; and cystometry, preoperatively, daily postoperatively (until discharge), and late postoperatively.

One hundred unselected cases in which vaginal hysterectomy was followed by postoperative urethral catheter drainage and 100, by postoperative trocar cystotomy drainage, were analyzed with regard to possible advantages of the latter type of management of postoperative bladder dysfunction. Surgical technique was as similar as possible in the entire series, consisting of vaginal hysterectomy with anterior and posterior repair. Oophorectomy, while done occasionally, was not considered as relevant to this article, nor were the actual findings of the pathologic specimens, except that all lesions were benign. Trocar cystotomy was performed by using the Campbell trocar. No. 18 French 5 cubic centimeter bag indwelling Foley catheters were used for both urethral catheter and suprapubic cystotomy drainage. The catheters were connected to straight drainage systems and irrigated only when necessary. Voiding was initiated in the urethral catheter group by removal of the catheter and by clamping off the suprapubic catheter in the trocar cystotomy group. Urinary retention in the former group was treated by repeat catheterizations, sometimes indwelling for 1 or more days; in the latter group it was necessary only to unclamp the cystotomy tube to provide relief. The suprapubic catheter was removed only when a normal voiding pattern had been attained with the tube clamped for 24 hours and no significant residual urine present. Bladder stimulants and sedatives were given only sporadically with no clinically apparent results. All patients received antibiotics for 5 days postoperatively.

RESULTS OF STUDY

Bladder function studies. Cystoscopic findings in general were not readily correlated with bladder symptomatology. Preoperatively, all cases demonstrated varying degrees of relaxation of the urethra and bladder neck, descensus of the trigone and base of the bladder together with occasional changes in the appearance of the mucosal and muscular layers which were difficult to evaluate. Postoperatively, the bladder base was seen to be elevated quite markedly, occasionally presenting an edematous aspect while the urethra and bladder neck were more rigid than preoperatively. In individual patients, however, these features were not always reconciled with symptoms of retention or stress incontinence, for example. Since cystoscopic data, because of its subjective nature, were difficult to assess, no conclusions were drawn from this phase of the study.

Cystographic studies were more helpful than cystoscopy in determining the degree of bladder prolapse. Roentgenographic evidence of funnelling of the bladder neck and descensus of the bladder base correlate well with findings on digital and speculum examination of the anterior vaginal wall and urethra in the individual patient. Cystographic studies on patient C. R. are shown in Figure 1. Comparison of preoperative and postoperative cystograms reveals elimination of the funnel-shaped vesical neck and elevation of the bladder base. Again cystographic studies appear to be primarily of academic interest in that the findings more or less duplicate those of physical examination and cystoscopy without adding insight into the basic cause of bladder dysfunction in the individual case.

Cystometry, while essentially a subjective examination, offers the best approach available to an objective study of bladder dysfunction following vaginal hysterectomy. Cystometry is a graphic record of bladder tone, capacity, and expulsive power performed by recording manometric pressures while filling the bladder at a constant rate. Serial cystometrograms are of great aid in determining changes in bladder function following surgery.

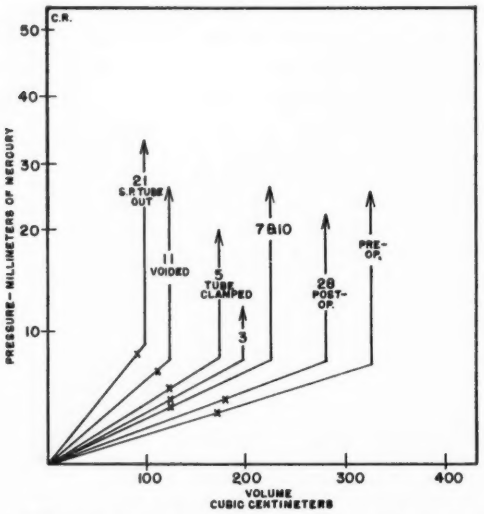


FIG. 2. Same patient as in Figure 1. Marked cystocele and urethrocele, minimal stress incontinence, no residual urine preoperatively. Serial cystometrograms: numerals enclosed in tracing lines indicate postoperative days. Note postoperative hypertonia, with return of maximal voiding contraction to preoperative level by day 7. Patient voided small amounts with tube clamped from day 11 through day 19, and residual urine gradually decreased from 100 to 60 cubic centimeters. Capacity nearly preoperative level by day 28. *X* indicates first desire to void.

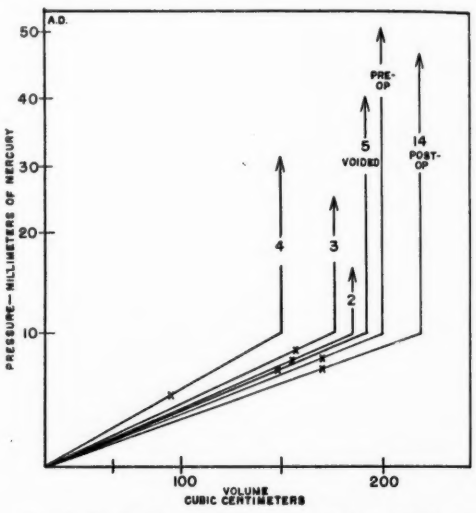


FIG. 3. Patient A. D. (urethral catheter). Moderate cystocele, no stress incontinence, 90 cubic centimeters of residual urine preoperatively. It can be noted from serial cystometrograms that there was a progressive increase in maximal voiding contraction on days 2, 3, 4, and 5 and that there was also an increase in bladder capacity on day 5 at which time the urethral catheter was removed. One hundred cubic centimeters of residual urine were reported on day 5; on day 14 no residual urine was present.

Preoperative and serial postoperative cystometrograms representing 5 patients are shown in Figures 2 through 6. In general the findings are representative of the entire group. Serial cystometrograms reveal, postoperatively, an initial reduction in bladder capacity and maximum voiding contraction. The maximum voiding contraction becomes progressively stronger and approaches preoperative levels by the fifth to seventh day. The bladder capacity remains less than before operation, and after the seventh day the cystometric picture not uncommonly is that of a "spastic" bladder. Those urethral catheter cases showing urinary retention or high residual urine on initial removal of the catheter demonstrate an immediate increase in the bladder capacity and reduction in maximum voiding contraction, strong evidence for bladder neck obstruction. In cystotomy cases, clamping of the tube and diverting urine through the normal urethral channel produced a less marked increase in the bladder capacity and reduction of maximum voiding contraction, since the patient was instructed to unclamp the cystotomy tube when bladder discomfort was not relieved by voiding so as to prevent overdistention. Cystometric curves taken in the late postoperative period, after normal voiding conditions had been obtained, demonstrated a close approximation to the preoperative tracings.

TABLE I.—AGE DISTRIBUTION OF URETHRAL CATHETER GROUP (UCG) AND TROCAR CYSTOTOMY GROUP (TCG)

Age, yrs.	*UCG No. of cases*	*TCG No. of cases*
20–29	1	3
30–39	20	26
40–49	37	25
50–59	21	23
60–69	14	17
70–79	4	5
80–89	3	1
Total	100	100
Average age, yrs.	49.5	48.9

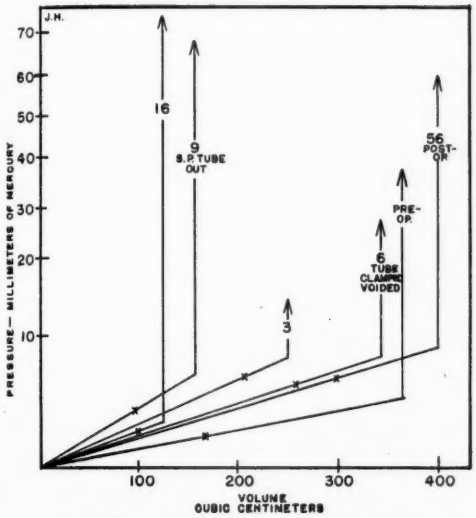


FIG. 4. Patient J. H. (trocar cystotomy). Moderate cystocele, minimal stress incontinence, 30 cubic centimeters of residual urine preoperatively. Serial cystometrograms: voiding small amounts, reduced residual from 100 to 50 cubic centimeters in interval between fifth and sixteenth postoperative days. Note extreme vesical hypertonia.

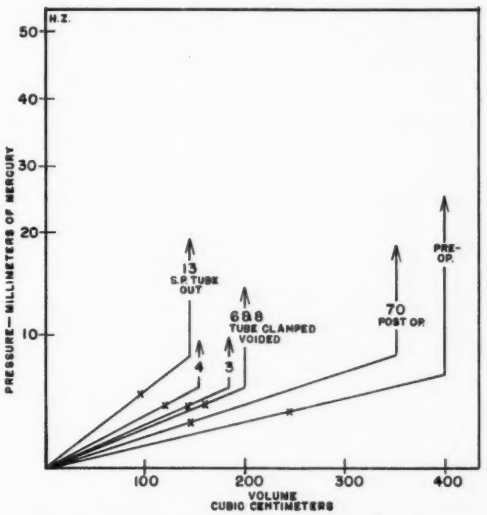


FIG. 5. Patient H. Z. (trocar cystotomy). Moderate cystocele, moderate stress incontinence, 20 cubic centimeters of residual urine preoperatively. Serial cystometrograms: note similarity of pattern to preceding cases. Residual reduced from 75 to 30 cubic centimeters from day 8 to day 13. Two episodes of retention after removal of cystotomy tube.

The first desire to void was recorded in all instances but appeared to have no bearing on the over-all problem. No evidence of impairment of sensation to heat and cold could be determined.

Urethral versus trocar cystotomy catheter drainage. The average age of 100 patients in the urethral catheter group was 49.5 years; in the trocar cystotomy group, 48.9 years. The age distribution in the two groups was similar (Table I).

Using as a standard a temperature of 100.4 degrees or higher on 2 consecutive postoperative days, the trocar cystotomy group showed a 5 per cent higher morbidity than the urethral catheter group (47 per cent in the former, 42 per cent in the latter). Morbidity for the entire series was 44.5 per cent. Obviously this "obstetrical" morbidity standard is rather strict, but it serves as a basis for comparative studies.

The median postoperative day on which the urethral catheter was removed or the cystotomy tube clamped to initiate normal voiding was the fifth day in both groups. The distribution curves show a tendency toward earlier clamping of the cystotomy tube, however.

The median postoperative day on which voiding first occurred (disregarding the actual quantity of urine voided) was the seventh day for the urethral catheter group and the eighth day for the trocar cystotomy group. The distribution curves indicate a

TABLE II.—DISTRIBUTION OF URETHRAL CATHETER CASES WITH REFERENCE TO NUMBER OF CATHETERIZATIONS REQUIRED BEFORE ONSET OF NORMAL VOIDING

No. of catheterizations	*UCG No. of cases*
0– 4	37
5– 9	28
10–14	16
15–19	8
20–24	4
25–29	3
30–34	2
35–39	—
40 or over	2
Total	100
Average No. of catheterizations	9.5

One patient required 65, another 62 catheterizations.

TABLE III.—DISTRIBUTION OF CASES WITH REFERENCE TO NUMBER OF NARCOTIC INJECTIONS REQUIRED AFTER FOURTH POSTOPERATIVE DAY

No. of hypos. given	*UCG No. of cases*	*TCG No. of cases*
None	55	36
1– 4	22	30
5– 9	19	17
10–20	1	14
20 or more	3	3
Total	100	100
Average No.	3.4	4.2

TABLE IV.—DISTRIBUTION OF CASES WITH REFERENCE TO AMOUNT OF RESIDUAL URINE ON DISCHARGE FROM HOSPITAL

Residual urine, oz.	*UCG No. of cases*	*TCG No. of cases*
0–2	46	39
2–4	32	32
4–8	10	10
Over 8	9	4
Not voiding	—	14
Not done	3	1
Total	100	100

Of 97 patients in the UCG, 52.6 per cent were discharged with more than 2 oz. of residual urine.
Of 99 patients in the TCG, 60.6 per cent were discharged with more than 2 oz. of residual urine.

TABLE V.—UROLOGIC AND NONUROLOGIC POSTOPERATIVE COMPLICATIONS

	UCG No. of cases	*TCG No. of cases*
Nonurologic	5	9
Vaginal hemorrhage	3	4
Cardiac complications	—	2
Thrombophlebitis	2	3
Urologic	2	12
Urethrovaginal fistula	2	—
Bladder calculi	—	7
Hematuria	—	4
Ruptured bladder	—	1

Mortality entire series (200 cases)—0.

moderate delay in initial voiding in the trocar cystotomy group.

The 100 patients in the urethral catheter group were catheterized an average of 9.5 times before satisfactory bladder function was obtained. The advantages of trocar cystotomy were most obvious, however, in those patients (35 per cent) requiring more than the average number of catheterizations. Two patients were catheterized more than 60 times. After removal of the suprapubic tube, an occasional cystotomy patient required one or more urethral catheterizations; this was a relatively infrequent occurrence (Table II).

TABLE VI.—RELATION OF TYPE OF ANESTHESIA TO MORBIDITY (TEMPERATURE ABOVE 100.4 DEGREES ON 2 CONSECUTIVE POSTOPERATIVE DAYS)

	—Morbidity— No.	*Per cent*	*No morbidity No.*	*Total No.*
UCG	42	—	58	100
Spinal	25	37.9	41	66
General	17	50.0	17	34
TCG	47	—	53	100
Spinal	28	38.9	44	72
General	19	67.9	9	28
Entire series	89	44.5	111	200
Spinal	53	38.4	85	138
General	36	58.1	26	62

TABLE VII.—RELATION OF TYPE OF ANESTHESIA TO POSTOPERATIVE DAY ON WHICH VOIDING FIRST OCCURS (QUANTITY OF URINE VOIDED DISREGARDED)

	——Postoperative voiding days—— 2–4	*5–9*	*10–14*	*15–20*	*over 20*	*Urine retention for 10 days or more, per cent*	*Total*
UCG							100
General	4	21	8	—	1	26.4	34
Spinal	6	45	10	4	1	22.8	66
TCG							100
General	3	10	9	5	1	53.6	28
Spinal	8	38	18	5	3	36.1	72
Entire group							200
General						38.7	62
Spinal						29.7	138

An attempt was made to analyze and compare the amount of postoperative discomfort due to bladder dysfunction; Table III indicates the number of narcotic hypodermics required, beginning with the fifth postoperative day, in each group. The trocar cystotomy group appeared to have experienced more discomfort than the urethral catheter group. It was thought, however, that catheterization in the urethral catheter group was used as a form of pain relief similar to the injection of a narcotic. Certainly the clinical impression is that the urethral catheter group experience more discomfort in regaining normal bladder function than the cystotomy patients.

Twenty-three patients in the cystotomy group were discharged with the tube in place to be removed later in the office. No urethral catheter patient was discharged with catheter in place. The fourteenth was the median day of removal of the suprapubic tube in the trocar cystotomy group.

As indicated in Table IV, the cystotomy patients had somewhat more residual urine

on discharge from the hospital than patients in the urethral catheter group. However, 14 cystotomy patients were not voiding at the time of discharge which fact tends to distort the figures.

The period of hospitalization for cystotomy patients averaged 1.6 days longer than for the group treated by urethral catheterization.

The cystotomy group contained 2 per cent more patients with preoperative bladder symptoms and 15 per cent more patients with postoperative bladder symptoms (on discharge) than the urethral catheter group.

Postoperative (on discharge) symptoms in the urethral catheter group were primarily frequency and burning; in the trocar cystotomy group, suprapubic pressure and retention. The best immediate result of surgery was in the cure of stress incontinence.

Bladder symptoms tended to be of longer duration in the urethral catheter group.

Bladder calculi in the cystotomy group have been controlled by irrigating the catheter with weak acid solutions. Urethrovaginal fistula is believed to be a complication of repeated urethral catheterizations (Table V).

The morbidity in patients receiving general anesthesia was 20 per cent higher than in those receiving spinal anesthesia (entire series). This could be attributed to unrecognized pulmonary complications and increased bleeding during surgery with hematoma formation. Further investigation seems indicated (Table VI).

Morbidity effected an appreciable prolongation of hospital stay, more marked in the urethral catheter group.

Patients receiving spinal anesthesia tended to void somewhat earlier than those receiving general anesthesia (Table VII).

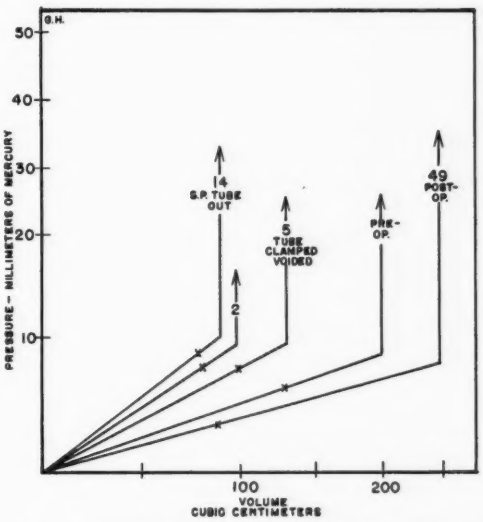


FIG. 6. Patient G. H. (trocar cystotomy). Moderate cystocele, minimal stress incontinence, 50 cubic centimeters of residual urine preoperatively. Serial cystometrograms: Note similarity of pattern to preceding cases. No residual urine after day 5. Small capacity bladder with minimal postoperative voiding difficulties.

DISCUSSION

Data derived from analysis of the clinical records of 200 unselected cases of patients treated by vaginal hysterectomy and repair, 100 of whom had urethral catheter drainage and the remaining 100, trocar cystotomy drainage postoperatively, indicate that trocar cystotomy as a form of temporary bladder drainage following vaginal hysterectomy is associated with slight increase in morbidity, prolongation of initiation of voiding and of hospital stay postoperatively, increase in residual urine on discharge, and increase in frequency of late postoperative bladder symptoms. Direct complications of trocar cystotomy have been bladder calculi (7 cases), hematuria (4 cases), and ruptured bladder (late) (1 case). Bladder calculi have recently been prevented by weak acid irrigations postoperatively.

Trocar cystotomy drainage has the advantages of less nursing care and increased patient comfort.

Obviously, trocar cystotomy will be of most value in those patients who have been afflicted with a long period of postoperative urinary retention. Serial bladder function studies performed on 15 patients treated by vaginal hysterectomy and repair indicated that vesical neck obstruction was the usual

cause of such retention. Thus it would seem reasonable to reserve trocar cystotomy for those cases in which extensive repair of the urethra and anterior vaginal wall is carried out for stress incontinence, and for those "nervous" patients who might be expected to react poorly to repeated urethral catheterizations.

The single contraindication to trocar cystotomy has been the history of previous surgery in the suprapubic region, with subsequent distortion of the normal anatomic relation of the structures.

SUMMARY

1. Preoperative and serial postoperative cystometric studies in 15 unselected patients treated by vaginal hysterectomy and repair indicate that: (a) Following temporary postoperative atony of the detrusor the voiding contraction approaches preoperative levels by the fifth to seventh days. (b) Postoperative bladder capacity is always less than before surgery. Spastic bladder phenomena are frequently associated with retention and residual urine. (c) Postoperative urinary retention and associated voiding difficulties are most closely related to vesical neck obstruction; i.e., surgical overcorrection, urethral edema, and sphincter spasm. (Long standing detrusor atony was not observed in this series.)

2. Trocar cystotomy drainage appears to be a valuable adjunct in the management of bladder dysfunction following vaginal hysterectomy, routinely or in selected cases in which a prolonged period of urinary retention is anticipated.

3. General anesthesia was followed by a 20 per cent higher morbidity than spinal anesthesia in the entire series of 200 cases.

4. Trocar cystotomy appeared to circumvent the postoperative urethritis which is so often a distressing sequel to indwelling urethral catheter drainage.

REFERENCES

1. Allen, E., and Peterson, L. F. Versatility of vaginal hysterectomy technique. Obst. Gyn., 1954, 3: 240.
2. Banks, L. A., and Rutherford, R. N. Vaginal hysterectomy: individual variation in technique and results. West. J. Surg., 1955, 63: 23.
3. Bertini, R. Vesical tone in pregnancy, with cystometric studies. Scritti in onore del Prof. Ercole Cova. Pp. 896-907. Torino: Minerva Medica, 1948.
4. Campbell, M. F. Urology. Vol. III, pp. 1891–1893. Philadelphia and London: W. B. Saunders Co., 1954.
5. Counseller, V., and Hunt, W. Indications, advantages, and surgical technique of vaginal hysterectomy. Surg. Gyn. Obst., 1954, 99: 761.
6. Falk, H. C., and Bunkin, I. A. A study of 500 vaginal hysterectomies. Am. J. Obst. Gyn., 1946, 52: 623.
7. Gray, L. A. Vaginal hysterectomy. Ann. Surg., 1954, 139: 666.
8. Halber, G., and Richter, K. Function of the bladder following radical surgery for cancer of cervix. Wien. med. Wschr., 1949, 99: 278–282.
9. Oehlert, G. Cystometric studies on the reaction of bladder pressure after radical Wertheim operation. Zbl. Gyn., 1954, 76: 1763-1765.
10. Quaini, P. I valori cistomanometrici a distanza dagli interventi per via vaginale. Minerva gin., Tor., 1954, 6: 387-390.
11. Idem. Studio endoscopico e funzionale dell apparato urinairo in donne operate di isterectomia e plastica per via vaginale. Minerva gin., Tor., 1954, 10: 381.
12. Idem. Indagini radiologicle delle vie urinarie e dell ultimo tratto dell intestino nelle operate di isterectomia per via vaginale. Minerva gin., Tor., 1954, 10: 390.

THE EFFECT OF OPERATIVE TRAUMA ON THE UTILIZATION OF THYROID HORMONE

IRA S. GOLDENBERG, M.D., PAUL J. ROSENBAUM, M.S.,
COLIN WHITE, M.Sc., M.B., and MARK A. HAYES, M.D., Ph.D., F.A.C.S.,
New Haven, Connecticut

ALTERATIONS in thyroid function resulting from operative trauma have been demonstrated by Goldenberg and associates (1–4). Evidence at the present time presumes the increased glandular activity to be the result of increased activity in pituitary release of thyroid-stimulating hormone as reflected by an increased radioactive iodine uptake by the gland as well as an increase in circulating protein-bound radioiodine after operation. It is possible, however, that an alteration in peripheral tissue utilization of thyroxine also may contribute to the varying patterns seen in the acutely and chronically ill patients who have been reported upon. The present study was designed to evaluate peripheral utilization of thyroxine subsequent to operation.

MATERIALS AND METHODS

Eight patients varying from 18 to 78 years of age were studied before and after major operations performed under general endotracheal anesthesia. Each patient was given a small amount (20 to 25 microcuries) of chromatographically pure radioactive thyroxine which was administered intravenously several days prior to operation. Samples of blood were obtained at 24 hour intervals following administration and the conversion ratio (PBI^{131}) was determined for each sample by methods previously described (3). To block endogenous thyroid hormone production and to prevent significant recirculation of the radioiodine, each patient was given Lugol's solution daily for 5 to 7 days at a dose level of 0.6 cubic centimeter 3 times daily prior to administration of the radiothyroxine. This dosage was continued during the entire course of study, an intravenous iodine solution being used in those instances in which the patient was unable to take oral fluids.

By utilizing the method of least squares, the statistical significance of the serial conversion ratio levels was determined. The slope of the best fitting line was ascertained by the formula:

$$\text{Slope} = \frac{\Sigma xY}{\Sigma x^2}$$

where x = deviation from mean time of drawing samples. (Since all patients had samples drawn daily for 5 days, the mean is 3 in all cases.)

Y = log of the conversion ratio

$$\left(\text{Conversion ratio} = \frac{\text{net counts PBI}^{131} \text{ in 2 ml. serum}}{\text{net counts in 2 ml. serum}}\right)$$

Σ indicates summation. After determining the slope of the best fitting line it was possible to ascertain the intercept of this line

$$\text{Intercept} = \text{mean Y} - (3 \text{ times slope})$$

and thence the prediction equation of the final plotting of the serial points (where Y is the predicted value of Y for any corresponding X).

$$Y = a + b\,X$$

where a = intercept, b = slope, X = arbitrary abscissa point (time).

From the Samuel C. Harvey Metabolic Unit, Department of Surgery, Department of Public Health, Yale University School of Medicine, New Haven, Connecticut.

This study was supported by a grant from the Josiah Macy, Jr. Foundation, by a contract between the Office of Naval Research, Department of the Navy, and Yale University School of Medicine, NR 105057, and by a grant from the Upjohn Company.

TABLE I.—SUMMARY OF RESULTS

Patient	Age, years	Operation	Chronic illness or recent acute stress	Slope of best fitting line		Intercept	
				Preop.	Postop.	Preop.	Postop.
A	61	Cholecystectomy	No	−0.092	−0.240	1.57	1.94
B	50	Craniotomy	No	−0.095	−0.326	1.58	1.95
C	57	Pneumonectomy	No	−0.035	−0.187	1.78	1.50
D	70	Pneumonectomy	No	−0.048	−0.142	2.05	1.90
E	78	Transthoracic repair hiatus hernia	Yes	−0.028	−0.026	1.62	0.99
F	72	Anterior resection colon	Yes	−0.197	−0.189	2.08	2.25
G	18	Thoracotomy with resection apical blebs	Yes	−0.061	−0.079	1.86	1.79
H	44	Subtotal gastrectomy	Yes	−0.050	−0.040	1.09	0.91

On the day of operation the final preoperative sample was drawn and immediately thereafter a second amount of radiothyroxine was given intravenously and a similar series of blood samples was drawn every 24 hours, and the conversion ratio of each was determined. A correction for decay of residual radioactivity was made in computing the postoperative values.

In this manner it was possible to determine the rate of thyroxine utilization in any individual subject before operation and to compute a similar utilization curve after operation. Any altered utilization of the labeled thyroxine in the postoperative period would suggest that operative trauma affects cellular metabolism of the hormone.

The possible effect of blood dilution after the second administration of radiothyroxine was eliminated by limiting all blood replacement to the time of operation and by taking the first postoperative sample 24 hours after the administration of the radiothyroxine at which time equilibration in body fluids had taken place.

Any patients whose blood pressure values reached shock levels for that individual during operation were eliminated from the study. All patients had normal blood nonprotein nitrogen values prior to operation and, therefore, were presumed to have normal renal function. The level of preoperative thyroid activity was of no concern here since the decay of exogenous labeled thyroxine alone was being studied. It was believed that any basic change in endogenous thyroid hormone production as a result of the operative stress would not affect the utilization of the labeled hormone since both would be consumed from a common hormone pool at the same rate.

RESULTS

The results obtained here were much the same as those noted previously in studies of thyroid glandular activation and the level of circulating thyroid hormone during operation. Four of the patients (A, B, C, and D) (Table I, Fig. 1) who had not experienced recent acute stress or long standing chronic illness displayed an increased utilization of the labeled thyroxine after operation. This effect is indicated by the significantly steeper line showing the diurnal change in the log of the conversion ratio. Patient A had essentially asymptomatic cholelithiasis, and an elective cholecystectomy was performed without event. Patient B had a large carcinoma of the right upper lobe of the lung with a solitary cerebral metastasis and was studied during craniotomy for excision of the superficial cerebral lesion. Bronchiectasis which had been mildly symptomatic for many months caused patient C to be hospitalized for a contemplated lobectomy. Technical difficulties, however, were encountered at operation and a pneumonectomy was done. A large and mildly symptomatic carcinoma of the lung was treated in patient D by pneumonectomy.

On the other hand, the remaining 4 patients (E, F, G, and H) (Table I, Fig. 2) had postoperative thyroxine utilization curves not significantly different from their pre-

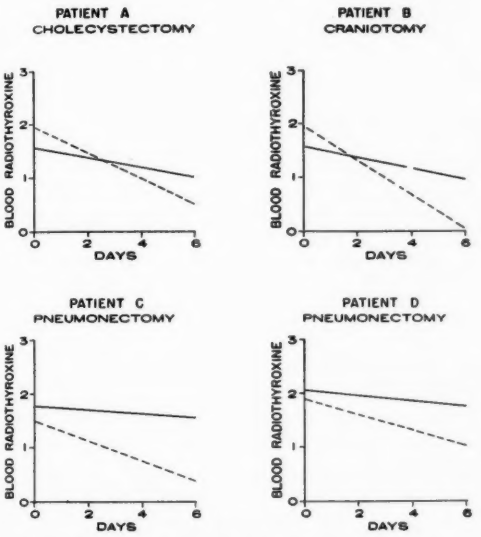


FIG. 1. Patients who displayed an increased utilization of thyroxine after operation. Solid line denotes preoperative and dashed line postoperative utilization. See text for details.

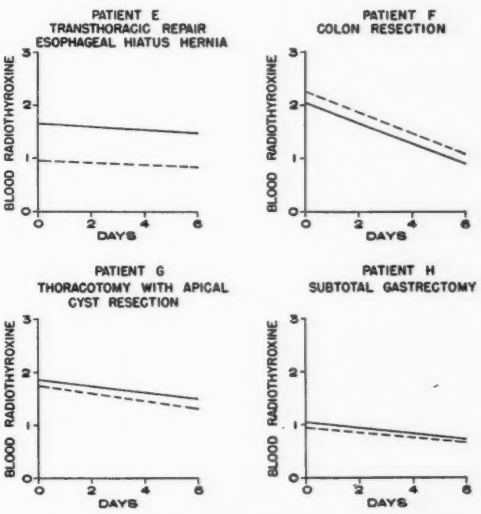


FIG. 2. Patients who did not display increased utilization of thyroxine after operation. Solid line denotes preoperative and dashed line postoperative utilization. See text for details.

operative curves. All of these patients had severe acute stress or had advanced chronic illness prior to study here. Patient E was admitted in shock after severe upper gastrointestinal hemorrhage from an esophageal hiatus hernia. Phrenic crush was performed under local anesthesia and bleeding was controlled. Transthoracic repair of the hiatus hernia was done 10 days later, and the patient was studied during the second operation. Patient F had a large carcinoma of the colon with metastases and chronic blood loss prior to anterior resection. Repeated episodes of spontaneous, bilateral pneumothorax prompted admission of patient G who had recent, partial collapse of both lungs. Preoperative chest drainage with a small plastic catheter was done and the patient later studied during anterior thoracotomy at which time apical congenital blebs were excised. The final patient (H) had a duodenal ulcer with intractable symptomatology and was studied here during hospitalization for subtotal gastrectomy.

DISCUSSION

The present study strongly suggests that an alteration in the peripheral cellular utilization of thyroxine follows operation. Therefore, it would appear that not only is a central thyroid gland activation present after operation, but also a change in the ultimate end-organ utilization of thyroxine. It is not clear at this time which of the series of reactions is primary—increased output of hormone by the gland or increased demand by the cells. The chain of events after operation may depend on a delicate balance between humoral and neural controls of homeostasis. Operative stress causes a generalized increased cellular demand for thyroid hormone by pathways not yet delineated. This increased demand affects the area of the hypothalamus devoted to influencing pituitary thyroid stimulating hormone production, as indicated by Ganong and associates. The thyroid gland then responds with increased output of hormone satisfying the new cellular demands. Important for the

intricate interrelated events to take place appears to be a "normal" organism. Chronic illness such as in patients E, F, and H upsets the balance so that the anticipated events already described do not follow. Recent acute stress, as in patient G, has the same effect. The complete basic response pattern after operation has now been demonstrated in all phases—increased thyroid glandular activity (increased uptake of radioactive iodine) (1), increased circulating thyroid hormone (higher levels of PBI^{131}) (3), and now increased peripheral use of hormone.

SUMMARY

Increased tissue utilization of thyroxine as measured with isotopically labeled hormone has been demonstrated to follow operation in patients who have not had recent acute stress or who are not chronically ill. Patients who fall into either of the latter categories do not display the same increase.

REFERENCES

1. Goldenberg, I. S., Lutwak, L., Rosenbaum, P. J., and Hayes, M. A. Thyroid-adrenocortical interrelations following operation. Surg. Gyn. Obst., 1954, 98: 513–522.
2. Idem. Thyroid-adrenocortical metabolic interrelations. J. Clin. Endocr. Metab., 1955, 15: 227–237.
3. Idem. Thyroid activity during operation. Surg. Gyn. Obst., 1956, 102: 129–133.
4. Goldenberg, I. S., Rosenbaum, P. J., and Hayes, M. A. Patterns of thyroid-adrenocortical response after operation. Ann. Surg., 1955, 142: 786–797.
5. Ganong, W. F., Fredrickson, D. S., and Hume, D. M. The effect of hypothalamic lesions on thyroid function in the dog. Endocrinology, 1955, 57: 355–362.

DIAGNOSTIC THORACOTOMY WITH TRANSDIAPHRAGMATIC ADRENALECTOMY FOR INTRATHORACIC RECURRENT BREAST CARCINOMA

EDWIN TUTT LONG, M.D., WILLIAM E. ADAMS, M.D., F.A.C.S., and PETER V. MOULDER, M.D., Chicago, Illinois

THE PATIENT with a previously treated carcinoma of the breast and an "indeterminate intrathoracic lesion" may be considered a poor candidate for diagnostic thoracotomy because of the low potential for therapeutic benefit from biopsy or removal of the lesion. This is especially true when there are foreboding signs, such as pleural fluid or diaphragmatic paralysis. However, vigorous hormonal and radiation therapy will usually be withheld until an exact diagnosis can be made. Such an exact diagnosis may, in some cases, be made only after some delay. Further manifestations of the recurrent carcinoma develop and the best opportunity for therapy may be missed.

The usefulness of the bilateral ovariectomy and adrenalectomy has been well established in the treatment of metastatic breast carcinoma. The combination of diagnostic thoracotomy and concomitant transdiaphragmatic unilateral adrenalectomy has been used in the handling of this type of problem and found to be useful and satisfactory. A second stage operation for removal of the remaining adrenal gland (and ovaries, if present) is performed 2 weeks after the first stage.

SELECTION OF PATIENTS

Evidence of metastatic lesions following radical mastectomy for carcinoma of the breast, in some cases, may first be observed on x-ray examination of the thorax. Such x-ray examinations may have been obtained either routinely or in response to some suggestive symptom. If the usual diagnostic measures, such as bronchoscopy, sputum cytologic and bacteriologic examinations, and scalene node biopsies, have failed to prove the diagnosis of recurrent carcinoma of the breast, diagnostic thoracotomy can be more readily considered with the added potential of accomplishing a part of the therapeutic program.

METHOD

The technique and ease of execution are the same for operations on the right and left sides. A thoracotomy incision in the sixth interspace is adequate for intrathoracic exposure and exploration and offers a satisfactory approach to the diaphragm if biopsy with microscopic frozen section confirms the diagnosis of recurrent carcinoma of the breast. The adrenal gland on the same side is reached through a radial posterior diaphragmatic incision approximately 5 to 6 centimeters long. In some patients the liver edge is encountered extending posteriorly to the margin of the ribs; in others there may be a sizable space between the posterior liver edge and the rib cage. The entire suprarenal space is cleaned out by dissecting the fat and connective tissue from the muscles, liver, peritoneum, and on the right side from along the vena cava. The fat is stripped from the upper pole of the kidney to the level of the renal vessels. On the right side the short adrenal vein to the vena cava is approached from an advantageous point and control of the vena

From the Department of Surgery, The University of Chicago School of Medicine, The University of Chicago, Chicago.

cava would be easy if tearing should occur. The less advantageous part of this approach occurs when the tissues are dissected to the level of the renal vessels, and when the inferior portion of the left adrenal vein at the renal vein level is handled.

This mass of tissue which contains the adrenal gland must be removed to obtain the not uncommon extra-adrenal cortical nodules which occur in this site.

Two weeks has been an optimal time to wait before removing the opposite adrenal gland through a lumbotomy incision. The ovaries, if present, are removed at this stage. The replacement schedule consists of 37.5 to 50 milligrams of oral cortisone and 2 grams of sodium chloride daily; 25 milligrams of desoxycorticosterone stearate (percortin) are given intramuscularly every 4 to 6 weeks, as indicated by examination of the extent of hypotension produced by rapid change from the recumbent to the standing position. The patient will reflect need for a shortened schedule by loss of strength, postural hypotension, and constipation.

CASE REPORTS

The following 4 cases illustrate the clinical situation in which this combination exploratory thoracotomy and transdiaphragmatic adrenalectomy can be of practical use.

CASE 1. A. I., a 58 year old white housewife, was admitted to Billings Hospital in May 1955 because of malaise, hoarseness, chills, fever, and cough developing over a 4 to 6 weeks' period. Two weeks before admission a film of the chest showed "congestion at the right base" which did not resolve with antibiotic therapy. In 1946 a right radical mastectomy had been performed for carcinoma of the breast.

The results of the diagnostic procedures were suggestive but not conclusive of a malignant growth. In May 1955 a right exploratory thoracotomy revealed a large tumor mass in the inferior portion of the hilum partially collapsing the bronchus of the right lower lobe and showing itself on the pleural surface posteriorly. Frozen section showed recurrent carcinoma of the breast; the right adrenal gland was immediately removed through the adjacent diaphragm. Three weeks later bilateral oophorectomy and left adrenalectomy were uneventfully performed. In May 1956, one year after her surgery, there had been no change in the x-ray appearance of the chest lesion. At this time the patient reported good strength and satisfaction with her condition.

CASE 2. M. F. T., a 52 year old white single female school teacher, was admitted to Billings Hospital in August 1955 because a routine chest film showed a pulmonary parenchymal nodule in the right lung base. A roentgenogram of the chest taken 6 months before, following an attack of "flu," was clear. She had smoked 15 cigarettes a day for many years and had a long-standing chronic cough. In December 1952, she underwent a left radical mastectomy for comedocarcinoma of the breast. No x-ray treatments had been given and no recurrences had been noted on regular follow-up examination.

The character of the pulmonary lesion was not revealed by the diagnostic measures. In September 1955, the parenchymal nodule was removed by wedge excision, and the frozen section showed metastatic carcinoma of the breast. Right adrenalectomy was then performed through the adjacent diagphragm. Two weeks later a bilateral oophorectomy and left adrenalectomy were performed through a low abdominal and left lumbar incision respectively. Recovery was uneventful.

The patient has reported good strength and has been teaching a full schedule. There are no signs of recurrence 9 months after surgery.

CASE 3. H. B., a 56 year old white female, was admitted to Billings Hospital in September 1955 because of shortness of breath and a 12 pound weight loss in 2 months. A roentgenogram of the chest revealed a large right-sided pleural effusion. Fifteen years previously she had had a right radical mastectomy for papillary cystic adenocarcinoma of the breast.

The diagnostic procedures, including pleural fluid cytologic studies, were not conclusive. In September 1955, a right exploratory thoracotomy revealed tumor nodules studding the right pleural cavity. Frozen section identified them as recurrent carcinoma. They were similar to the breast lesion removed 15 years previously. A transdiaphragmatic right adrenalectomy was immediately performed. After 2 weeks a bilateral oophorectomy and left adrenalectomy were carried out. The recovery was uneventful.

When last seen 7 months later, her weight loss had been restored and the patient was working as a full-time sales manager with good strength and no recurrence of pleural effusion or dyspnea.

CASE 4. F. U., a 54 year old negro male, was admitted to Billings Hospital in October 1955 because of weight loss of 20 pounds and a severe cough for 6 months. The sputum was occasionally streaked with blood. A roentgenogram of the chest showed both lungs massively invaded by "metastatic tumor." In

1942 the patient had a right radical mastectomy for "a large tumor." The histopathology could not be determined because the records had been destroyed in a hospital fire.

The diagnostic procedures did not yield a positive diagnosis of the tumor type. In November 1955, a right thoracotomy was performed. The lung was massively studded with tumor nodules. Biopsy and frozen section showed a recurrent adenocarcinoma of the breast. A right-sided transdiaphragmatic adrenalectomy was then performed. Two weeks later the left adrenalectomy was done. Recovery was uneventful.

In April 1956, he reported a weight gain and a good appetite. His cough had persisted and strength was "fair."

DISCUSSION

The operation consisting of exploratory thoracotomy and concomitant transdiaphragmatic homolateral adrenalectomy for those patients who have intrathoracic recurrent carcinoma of the breast is advantageous in several ways: First, it permits an accurate histologic diagnosis in an obscure lesion. Secondly, it initiates treatment without delay. Thirdly, it reduces the surgical trauma incident to accomplishing the same end result in separate stages. Lastly, experience has shown that healing and recovery after the combined operation are as satisfactory as after thoracotomy alone. After the opposite adrenalectomy is completed in a second stage, the management of the patient is in no way altered because of the combined procedure used in the first stage.

SUMMARY

A combination operation is recommended for patients having intrathoracic lesions which are possibly recurrent metastatic carcinoma of the breast.

This procedure consists of exploratory thoracotomy with biopsy and frozen section, and concomitant transdiaphragmatic homolateral adrenalectomy, if frozen section reveals recurrent carcinoma of the breast. Subsequent removal of the remaining adrenal gland (and ovaries, if present) is performed in 2 weeks.

BENIGN TUMORS OF THE LIVER

V. Traumatic Cysts

STANLEY W. HENSON, JR., M.D., GEORGE A. HALLENBECK, M.D., F.A.C.S., HOWARD K. GRAY, M.D., F.A.C.S., and MALCOLM B. DOCKERTY, M.D.,

Rochester, Minnesota

RUPTURE OF THE LIVER usually results in immediate and continued hemorrhage that requires prompt surgical intervention. Intrahepatic rupture, however, may result in the formation of large cystic cavities filled with blood or bile-stained fluid. It is thought that these cavities originally contain blood and bile in varying amounts and that the bleeding stops, whereas the flow of bile continues. Large cavities gradually are formed that usually produce symptoms only after a considerable interval of time subsequent to the injury.

Traumatic cysts of the liver are rare. However, because of the increased number of automobile and industrial accidents, greater incidence of such cysts may be anticipated.

Search of the files of the Mayo Clinic disclosed records of 5 patients with traumatic cysts of the liver; 2 of these have been reported upon previously by Hallenbeck and Fricke. The present paper represents the fifth part of a study on cases of benign tumors of the liver encountered at the clinic from 1907 to 1954, inclusive.

REVIEW OF THE LITERATURE

In 1898, Whipple reported a traumatic bile cyst of the liver occurring 1 week after the patient was kicked in the abdomen by a horse. Later in the same year, Aldridge reported a similar case in a young army officer who experienced sudden pain in the right hypochondrium while training a polo pony. Blood and, later, bile were aspirated on several occasions before infection developed in the cavity; the patient died of sepsis.

In 1903, Doran reported on a woman, 3 months pregnant, who fell against the edge of a washing tub and aborted the same day. Jaundice developed 2½ years later, followed in a few months by pain in the right upper abdominal quadrant. Operation disclosed a large cyst containing about 1,250 cubic centimeters of pure bile and involving the right lobe of the liver.

Andersson reported on a 36 year old laborer who was run over by an automobile. He was operated on 4 days after the injury because of sudden collapse and was found to have a delayed rupture of the spleen. He was explored surgically again 3 weeks later for what was thought to be a subphrenic abscess; this operation revealed an intrahepatic abscess with an intact hepatic capsule. The author interpreted this lesion to represent a subcapsular rupture of the liver with formation of a cyst that subsequently had become infected.

Brandberg reported on a 14 year old boy who was successfully operated on for a large traumatic bile cyst 30 days after he had been struck by a bus while riding a bicycle. Wulsten had a similar patient who was treated conservatively but who died several weeks after colliding with a fence while riding a sled. Necropsy disclosed that in the right lobe of the liver was a cavity the size of a child's head. The cavity contained greenish blood clots; the capsule of the liver was intact.

From the Section of Surgery and the Section of Surgical Pathology, Mayo Clinic and the Mayo Foundation, Rochester, Minnesota.

Abridgment of thesis submitted by Dr. Henson to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

Curran and Goodale successfully evacuated a large pseudocyst filled with bile 5 weeks after a patient had been treated for shock of unknown cause. Known injury to the abdomen had not occurred.

Robertson and Graham (10) reported 2 instances of traumatic subcapsular rupture of the liver. Symptoms developed early (within 30 hours) in the first patient, and the cavity in the liver was found at operation to be filled with blood. Symptoms appeared in the second patient after 27 days, and the cavity in the liver was found to contain blood and bile. These authors concluded that the contents of a tumor occurring soon after injury would be blood and that drainage with a tube would be the ideal method of handling such a lesion. If, on the other hand, the tumor was late in forming, bile would constitute an important part of its contents and marsupialization would be the preferred treatment. Robertson (9) later reported on a patient who was operated on 24 days after having been hit by an automobile. A cavity containing 250 cubic centimeters of pus was found in the liver; pneumococci were obtained on culture of the pus. He considered that this represented a traumatic cyst which had become infected secondarily by way of the blood stream.

Jones collected records of 61 cases of nonparasitic cysts of the liver and noted a history of trauma in only 4 cases. Injury appeared to be of etiologic significance in only 1 of these 4 cases, namely that of Doran already mentioned. Jones concluded that it was theoretically possible for an injury to cause rupture of a bile duct or to produce hemorrhage into the liver, which may be followed by formation of a pseudocyst, but he did not consider that such traumatic genesis could be proved.

Wright and associates presented 32 cases of traumatic rupture of the liver without penetrating wounds. They classified such cases into 4 main groups, namely: (1) massive hemorrhage with sudden death, (2) acute hemorrhage with early and progressive shock, (3) repeated small hemorrhage with intermittent or delayed occurrence of symptoms that may become manifest from 1 day to several months after injury, and (4) spontaneous cure.

Christopher classified rupture of the liver according to the location of the lesion into: (1) rupture of hepatic tissue and capsule, (2) subcapsular rupture (tearing of hepatic tissue without rupture of the capsule) and (3) central rupture of hepatic tissue. He reported on a 14 year old girl who had fallen on a picket fence and sustained a subcapsular rupture of the liver. Operation less than 24 hours later disclosed a subcapsular cyst of the liver that spontaneously ruptured while the patient was on the operating table.

PRESENT STUDY

As already indicated, study of the records at the clinic disclosed 5 cases of traumatic hepatic cysts. In Table I is presented a summary of some of the data in these cases.

Clinical features. Four children, aged 2, 2½, 4, and 6 years, respectively, and a 42 year old woman were included in our series. Two of the patients were male and 3 were female.

The trauma that produced the hepatic injury in the children was rather severe. Two were hit by automobiles, 1 was struck by a falling board, and 1 fell off a horse. The woman fell while walking with her arms full of packages. The children all recovered from the initial injury and appeared to be well for varying periods. They then experienced gradual development of anorexia, increasing distention, and intermittent abdominal pain. One child had clay colored stools and dark urine. Repeated paracentesis by her home physician produced large amounts of bile on several occasions. Operations were done on the 4 children at periods ranging from 11 days to 4 months after the injury. The woman had severe abdominal pain and dyspnea immediately after her fall and was unable to get up. She was explored surgically by her home physician within a few hours after injury; an acute rupture of the gallbladder was found, for which drainage was started. Her chief complaint on admission here was continuous drainage of bile for 6 months.

TABLE I.—FIVE PATIENTS WITH TRAUMATIC HEPATIC CYSTS OPERATED ON AT THE MAYO CLINIC

	Clinical features						
Case	*Sex and age, yrs.*	*Complaint*	*Type of injury*	*Delay from injury till operation*	*Treatment*	*Lesion, contents and size*	*Follow-up, yrs.*
1	F6	Pain, fullness	Hit by car	1 mo.	Marsupialized to abdominal wall	Bile; 25 cm. in diameter	18
2	F2	Distention, pain	Hit by falling plank	4 mos.	Incised, cavity packed	Bile (perforated); 2,000 c.c.	16
3	M2½	Pain	Hit by car	1 mo.	Incised and drained	Bile (perforated); 15 cm. in diameter	6
4	F42	Postoperative fistula	Fell with packages	6 mos.	Partial excision and packing	Pus; 300 c.c.	10
5	M4	Pain, distention	Fell off horse	11 days	Drained with T tube	Bile; 400 c.c.	—

On examination, all 4 children exhibited abdominal distention. A soft tender mass filled the entire right side of the abdomen and extended to the pelvis in each of 2 children, whereas a similar mass was confined to the epigastrium in another. Free ascitic fluid in the fourth child made it difficult to palpate the liver and one could not be sure whether or not hepatomegaly was present. The adult patient showed signs of having lost much weight and had a recent right subcostal scar with a biliary fistula.

Laboratory data. Direct-reacting bilirubin was increased in 3 patients and normal in 1; it was not determined in the fifth patient. Roentgenograms of the abdomen revealed an elevated diaphragm in 3 patients, with soft tissue masses being noted in 2 of these. Roentgenologic abnormalities were absent in the other 2 patients.

Diagnosis. The preoperative diagnosis was a cystic mass in the right upper abdominal quadrant in 1 patient, traumatic injury to the biliary system with bile peritonitis in 1, subcapsular hemorrhage of the kidney or liver with peritoneal irritation in the third, an external cholecystic fistula in the fourth, and a traumatic cyst of the liver containing blood or bile in the fifth.

Operative findings. At operation, a large cystic mass filled with bile was found to involve the right lobe of the liver in each of the 4 children. Two of these had had free perforation of the cyst, resulting in the presence of bile in the peritoneal cavity. The adult patient had a fistulous tract leading to a large cavity that apparently passed through the middle of the liver and up along the falciform ligament to the diaphragm. It was filled with pus.

All the cysts were large, ranging in size up to one that was 25 centimeters in diameter; 1 lesion was estimated to contain 2,000 cubic centimeters of fluid.

Material for biopsy was taken during operation in 3 cases. The walls of the cyst showed chronic inflammatory changes with varying amounts of fibrous tissue and mild to moderate infiltration with lymphocytes in 2 instances. The infected cyst showed an intense inflammatory reaction and infiltration with polymorphonuclear leucocytes. There was no epithelial lining in any of the 3 cysts studied microscopically.

Treatment. Treatment consisted of incision and packing of the cavity in 1 patient, incision and drainage in 1, partial excision and packing of the remainder of the cavity in 1, marsupialization of the cyst to the abdominal wall in the fourth patient, and drainage of the cyst by means of a T tube for 5 weeks in the last. The surgical incisions in the 4 children healed promptly. The infected cyst in the adult required repacking on 3 subsequent occasions at intervals of 2 to 3 weeks. The cavity gradually diminished in size and the drainage finally stopped.

The results of treatment have been satisfactory in all patients, although subsequent operations for stricture of the common bile duct were required in 2 patients. One of these patients underwent cholecystogastrostomy 6 months after her initial operation. The other patient had a choledochoduoden-

ostomy 10 years after drainage of the infected hepatic cyst; at the time of this last operation, another cyst was found in the right lobe of the liver that measured 7.5 centimeters in diameter and contained bile. This cyst was drained as the previous one had been.

Four patients have been followed for periods ranging from 6 to 18 years, with an average of 12 years. All were well when last heard from. The fifth patient was operated on only recently. Gentle suction was applied to the T tube draining his cyst for a few days after operation, during which time approximately 100 cubic centimeters of bile were obtained daily. Use of the suction was discontinued, and the drainage gradually diminished and stopped. The T tube was removed 5 weeks after operation and no further drainage was noted. The wound healed satisfactorily.

COMMENT

Our experience with traumatic cysts of the liver has been similar to that reported by other authors. The trauma required to produce such cysts is usually severe, although the patient reported on by Curran and Goodale had sustained no injury. Their case is unique in this respect.

The delay between the time of injury and the onset of symptoms referable to the liver varies from a few hours to several months or even years, although persistence of vague abdominal complaints is the usual course of events after the injury. In the remarkable case reported by Doran, a delay of 2½ years was noted before the onset of jaundice, with a further delay of 6 months before a large cyst involving her liver and containing bile was found at operation.

The clinical manifestations include pain in the abdomen, frequently referred to the shoulder, a tumor that usually can be palpated, and occasional jaundice. Roentgenograms often show an elevated diaphragm or a soft tissue mass that may displace adjacent viscera in a significant number of cases.

At operation, the cyst usually is located in the right lobe of the liver, with a great variation in size. The contents of the cysts may be composed of blood, bile, or pus, depending on the character of the channels that are disrupted, to some extent on the duration of the cyst, and on whether or not the contents have become secondarily infected. If the cyst perforates, free bile escapes into the peritoneal cavity and large quantities of the bile may be obtained by repeated paracentesis.

Simple drainage appears to be adequate treatment in the majority of cases, although marsupialization of the cyst to the abdominal wall, repeated packing, intermittent irrigation, and drainage of the cavity by means of a tube have been described and used successfully.

It is interesting that 1 of our patients was operated on for acute rupture of the gallbladder shortly after injury and the patient reported on by Andersson was operated on for delayed rupture of the spleen 4 days after injury, yet the hepatic cyst was not seen at the first operation in either patient. One assumes that the cyst had not yet achieved sufficient size to be palpable.

SUMMARY AND CONCLUSIONS

Five patients with traumatic cysts of the liver have been encountered at the Mayo Clinic from 1907 to 1954, inclusive. Data on 11 patients with similar cysts who have been reported upon in the literature have been reviewed.

Traumatic hepatic cysts are rare. They usually follow rather severe abdominal trauma, and the symptoms may be delayed for several months after injury. Clinical manifestations include abdominal pain, which frequently is referred to the shoulder, a tumor that is usually palpable and, less frequently, jaundice.

The cyst is located in the right lobe of the liver in most instances, and its contents may be blood, bile, or pus. If the cyst has perforated, free bile may be found in the peritoneal cavity.

Adequate surgical drainage appears to give excellent results.

REFERENCES

1. Aldridge, A. R. Rupture of the liver; cyst containing bile-stained fluid. Lancet, Lond., 1898, 1: 1616.
2. Andersson, Louis. Ueber zentrale Leberrupturen und ihre Komplikationen, vorzugsweise Abszesse. Beitr. klin. Chir., 1925–1926, 135: 696–710.
3. Brandberg, Rudolf. Beitrag zur Klinik der traumatischen Leberverletzungen bei unverletzter Kapsel. Acta chir. scand., 1928, 63: 321–345.
4. Christopher, Frederick. Rupture of the liver. Ann. Surg., 1936, 103: 461–464.
5. Curran, J. F., and Goodale, R. H. Traumatic bile cyst of liver. N. England J. M., 1932, 207: 1192–1193.
6. Doran, A. H. G. Large bile cyst of the liver. Lancet, Lond., 1903, 2: 1218–1220.
7. Hallenbeck, G. A., and Fricke, R. W. Traumatic bile cyst of the liver; report of 2 cases. Proc. Mayo Clin., 1950, 25: 648–651.
8. Jones, J. F. X. Removal of a retention cyst from the liver. Ann. Surg., 1923, 77: 68–89.
9. Robertson, D. E. Rupture of the liver occurring without tear of the capsule. Ann. Surg., 1937, 106: 467–469.
10. Robertson, D. E., and Graham, R. R. Rupture of liver without tear of capsule. Ann. Surg., 1933, 98: 899–903.
11. Whipple, C. A case of traumatic rupture of the liver; formation of cystic swelling containing bile-stained fluid; incision and drainage; recovery. Lancet, Lond., 1898, 1: 719.
12. Wright, L. T., Prigot, Aaron, and Hill, L. M., Jr. Traumatic rupture of the liver without penetrating wounds; a study of 32 cases. Arch. Surg., 1947, 54: 613–632.
13. Wulsten, Joachim. Zur Klinik und Pathologie der zentralen Leberruptur. Beitr. klin. Chir., 1931, 153: 424–436.

THE EFFECT OF HYSTERECTOMY ON YOUNG WOMEN

WARREN M. JACOBS, M.D., F.A.C.S., HAROLD I. DAILY, M.D., and
SEWARD H. WILLS, M.D., F.A.C.S., Houston, Texas

In 1956 we reported 68 cases in which hysterectomy, with and without adnexal removal, was performed upon women under 30 years of age (3). These represented 12.1 per cent of 568 hysterectomies performed on the Gynecological Service of the Baylor University College of Medicine, at Jefferson Davis Hospital, Houston, Texas, during a 30 month period from January 1953 through June 1955. We stated that this more complete type of pelvic surgery should, to some extent, replace the partial, incomplete, and often "tinkering" surgery heretofore practiced, especially with patients in whom the nature of the pelvic disease has made future pregnancies impossible, or in whom the disease itself is the result of multiple pregnancies. In the conclusions of this earlier report we stated that a study was in progress to evaluate the final results from a physical and psychologic standpoint.

MATERIALS AND METHODS

Of the original 68 cases previously reported, 46 were available for this present study. The duration of this follow-up study was from 1 to 2½ years following surgery. The patients were all interviewed by one of us (H. I. D.), and the following questions were formulated: (1) Do you feel that your operation was worth while, and are your symptoms relieved? (2) Has the operation affected your sexual life? (3) Are you concerned about having no future menstrual periods? (4) Are you concerned that you will not be able to become pregnant? (5) Do you have any hot flushes or extreme nervousness, and, if so, do you take any treatment for these symptoms? These questions were put to the patients specifically as stated, care being taken not to influence the answer by any leading type of question.

From the Department of Obstetrics and Gynecology, Baylor University College of Medicine, and the Gynecological Service at Jefferson Davis Hospital, Houston.

RELIEF OF SYMPTOMS

Forty-two patients were completely relieved of their symptoms, 3 were partially relieved, and 1 patient stated that she had not been helped at all by the surgery, but added "I am glad I had it because I do not want any more children." This latter patient was a 30 year old para 8-2-0-6, who had had a vaginal hysterectomy with anterior and posterior repair for uterine prolapse, cystocele, and rectocele. She stated that she had had lower abdominal pain before surgery and still had it, but freely admitted that she had many emotional problems and felt that many of her complaints were on this basis.

As stated, 3 patients experienced only partial relief: 1 of these was a 29 year old para 3-0-0-3, whose condition was diagnosed as chronic pelvic inflammatory disease, and a total abdominal hysterectomy with a left salpingo-oophorectomy and right salpingectomy was performed, the right ovary being left in situ. The patient stated that she still had occasional pain in the right side, but of no real severity, and a subsequent examination failed to reveal any physical cause for it. The second patient in this group had a total abdominal hysterectomy for large myomas, both ovaries and tubes being left in situ. The patient still complained of some lower abdominal discomfort, less severe, however, than before surgery. Examination failed to reveal any physical cause for her discomfort. The third patient had a total abdominal hysterectomy for reasons of persistent bleeding and severe pain. This patient had had a bilateral salpingectomy several years previously for recurrent salpingitis. Following hys-

terectomy the patient still complained of some abdominal discomfort, and on examination a cystic mass measuring approximately 4 centimeters in diameter was discovered in the right aspect of the cul-de-sac. This condition was thought to be of an inflammatory nature and was treated with antibiotics and hot sitz baths.

Four patients in our original series were operated on for pelvic pain believed to be due to the "pelvic congestion fibrosis syndrome"; 3 of these patients were available for follow-up study, and all 3 reported complete relief of pain following hysterectomy. Previous therapy had completely failed to relieve them of pain, and since this syndrome is rather poorly understood it was believed that special mention of these cases should be made.

EFFECT ON SEXUAL RELATIONS

Twenty-eight patients reported no change in their sexual life. These patients experienced the same satisfaction both before operation as after it. Seven of them had had both adnexa removed. None of the 28 patients had experienced dyspareunia prior to surgery. Thirteen patients experienced more satisfaction following the operation, and since all 13 had been having extreme dyspareunia prior to surgery and were relieved of this symptom, we believe that surgery was an important contributing factor to their increased sexual satisfaction. Five patients reported that sexual relations were slightly less satisfactory, but not markedly so, and they were not unduly concerned. Two of these patients had had a total abdominal hysterectomy and bilateral salpingo-oophorectomy for large myomas and chronic pelvic inflammatory disease. Three others had had a total abdominal hysterectomy for frequent and profuse bleeding with severe dysmenorrhea, and all 3 of them had had previous bilateral salpingectomy for chronic pelvic inflammatory disease.

FUTURE PREGNANCY

Forty-four of these patients were not concerned over their loss of fertility. Only 2 were worried about this factor. One of these was a para 5-1-0-4, with the diagnosis of "pelvic congestion fibrosis syndrome." Although she admitted that she felt much better since the surgery had been performed and considered it worth while, she was still concerned about the loss of her fertility. The other patient was a para 0-0-0-0 with large myomas and pelvic inflammatory disease. She was obviously sterile prior to the surgery, and the loss of the uterus cannot be associated with her concern on this score.

LOSS OF MENSTRUAL FUNCTION

Not a single patient expressed concern over the loss of menstrual function per se, in fact, practically all volunteered the information that they were very happy at the prospect of not being worried with further menstruation.

VASOMOTOR SYMPTOMS

Twenty-seven patients reported no vasomotor symptoms whatsoever. Nineteen reported mild to moderate symptoms, quickly relieved by mild sedation. There was no case of severe vasomotor symptoms among the 46 patients re-evaluated in this study.

Of the original group of 23 patients with both adnexa removed, 12 were available for this study. Eight of these patients claimed mild to moderate vasomotor symptoms, relieved by mild sedation. None of these patients was placed on substitutional estrogen therapy, but in the light of the most convincing recent work of Griffith regarding the relationship of oophorectomy to cardiovascular disease, our current feeling is that failure to utilize substitutional estrogen therapy may be a mistake. Our future policy will be to provide such patients with substitutional estrogen therapy in small oral doses whether symptoms warrant it or not.

DISCUSSION

From this study we conclude that the more complete type of pelvic surgery provides much better over-all results than does partial surgery, leaving behind as it does a nonfunc-

tioning uterus simply because a patient happens to be youthful. This fact has been observed by Ellison in similar studies. We believe it is most logical, if the pelvic disease present has made future pregnancies impossible, that any type of pelvic surgery for such disease should include a total hysterectomy provided that the patient is in good physical condition and has been made aware of the procedure and agrees to it beforehand. Regarding young women with symptomatic uterine prolapse, cystocele, and rectocele, it is our belief that vaginal hysterectomy with repair is the method of choice. If such a patient desires more children, we defer any surgery until the family is complete. Only in rare cases do we resort to the Manchester operation.

In spite of the fact that a diagnosis of "pelvic congestion fibrosis syndrome" is made not infrequently, we are still somewhat confused about this condition. Although all the patients in our series were relieved by hysterectomy, having received no relief previously by any form of conservative therapy, we still believe that this syndrome requires more study and that hysterectomy in such cases should be approached only with caution.

SUMMARY

1. A follow-up study of hysterectomy performed upon women of 30 years of age and under is presented.

2. The indications for performing it are reiterated.

3. The need is stressed for further studies concerning certain problems relating to this subject.

REFERENCES

1. ELLISON, EUGENE T., and THORNTON, W. D. Late results of pelvic surgery. South. M. J., 1954, 47: 913–918.
2. GRIFFITH, GEORGE C. Oophorectomy and cardiovascular tissues. Obst. Gyn., 1956, 7: 479–482.
3. JACOBS, WARREN M., and DAILY, HAROLD I. Hysterectomy in young women. Surg. Gyn. Obst., 1956, 102: 539–542.

NOVOBIOCIN THERAPY OF PYOGENIC SURGICAL INFECTIONS

EDWIN J. PULASKI, M.D., F.A.C.S., and ROBERT K. ISOKANE, M.S.,
Medical Corps, United States Army

NOVOBIOCIN is a new antibiotic isolated from cultures of Streptomyces species which was independently discovered in the research laboratories of 3 pharmaceutical companies and marketed by 2 of them under the names, albamycin and cathomycin. Its chemical structure has been identified by Hoeksema as a carbamate ester of a sugar derivative, the monosodium salt of which is used clinically. Novobiocin is unique in several respects. (1) Staphylococci are the most susceptible and uniformly sensitive of the different bacterial species regardless of their sensitivity or resistance to older antibiotics, whereas the in vitro sensitivities of the hemolytic and nonhemolytic streptococci vary widely, and the various gram-negative bacilli are among the least sensitive to its action. (2) The rate of emergence of resistant staphylococci in vitro is rapid, and there is some evidence that staphylococcal resistance may occur in vivo. (3) In vitro activity is decreased by more than 90 per cent in the presence of serum, due to binding by serum albumin. (4) Higher concentrations are attained in the blood, dose for dose, than for any other antibiotic, and these are well sustained, possibly owing to biliary excretion and reabsorption; little—about 3 per cent—is excreted in the urine. (5) In the clinical trials reported by Nichols and Finland the drug appeared to be well tolerated except that about 8 per cent of the patients after a week developed a generalized pruritic maculopapular rash, sometimes with fever, and in a few patients treatment had to be abandoned for this reason. There was general agreement regarding the efficiency of this drug in staphylococcal and some other coccal infections, whereas results in urinary tract and other infections due to Proteus species and coliform bacilli were varied.

This article is a report of bacteriologic and clinical studies of the albamycin preparation of novobiocin in 106 hospitalized patients with a variety of pyogenic surgical infections. Most were adults but 12 were between the ages of 1 week and 7 years. Cultures of exudate were taken whenever possible before and at intervals during treatment and subcultures were tested (agar plate—medicated disc method)[1] simultaneously to novobiocin and the older antibiotics. Sensitivity tests also were made on 100 strains of staphylococci isolated from the nares of 134 hospitalized patients. Also, studies of the binding effect of serum were made on in vitro sensitivities of staphylococci. In the clinical trials, the monosodium salt of novobiocin, supplied in 250 milligram capsules, was used in adults and the pediatric dosage form (100 mgm. per 5 c.c. of syrup) in infants and young children. In a few instances we have administered 500 milligrams of novobiocin by the intravenous route for 1 or more doses without apparent ill effects.

RESULTS

Laboratory studies. The results of sensitivity tests on 116 strains of Micrococcus aureus isolated from wound exudates and on 100 strains isolated from the nares of hospitalized patients are listed in Table I. The results

From the Department of Surgery, Tripler Army Hospital (Honolulu), APO 438, San Francisco, California.

Study aided by a Grant from the Research and Development Division, Surgeon General's Office, for the Study of Infections.

[1]Commercially prepared discs in the following concentrations per disc: bacitracin, 1 unit; chloramphenicol, 10 micrograms (mcgm.); erythromycin, 10 mcgm.; penicillin, 1 unit; streptomycin, 10 mcgm.; tetracycline, 10 mcgm.; and novobiocin, 5 mcgm.

were reported as "sensitive" (clear zone of inhibition around the disc), "partially sensitive" (incomplete inhibition around the disc), or "resistant" (no zone of inhibition). The stains resistant to novobiocin by this method were subjected later to quantitative (broth-serial dilution) tests. Only 3 of these 216 were resistant to novobiocin. One strain originated in an acutely inflammed sebaceous cyst, the other in a hydradenitis suppurativa, and the third in the nares of a patient newly arrived in the hospital. On further testing none of these 3 strains was inhibited in the presence of 100 micrograms per milliliter of novobiocin; they were sensitive only to erythromycin. These multiple drug-resistant strains exhibited enlargement of the cells on stained smears as compared with the strains which were sensitive to most or all of the antibiotics; there was no correlation between colony size, coagulase production sugar fermentation, or pigment production between the two groups.

In order to gain insight into the relative need for more antistaphylococcal drugs, data on the penicillin-resistant and the tetracycline-resistant strains of Micrococcus aureus were reassembled as shown in Table II. It will be noted that over 90 per cent were susceptible to erythromycin and over 80 per cent were susceptible to chloramphenicol. Only 6 strains were resistant to all the antibiotics except novobiocin.

The numerical results of in vitro novobiocin sensitivities against other species of microorganisms were as follows: beta hemolytic streptococci (14), 11 sensitive, 2 intermediate, 1 resistant; nonhemolytic streptococci (29), 22 sensitive, 2 intermediate, and 5 resistant; escherichia coli (17), 2 sensitive, 1 intermediate, and 14 resistant; pseudomonas species (16), 2 sensitive, 7 intermediate, and 7 resistant; coliform bacilli (14), 2 sensitive and 12 resistant; and proteus species (8), 3 sensitive and 5 resistant.

The binding effects of serum on novobiocin reported by others were confirmed by our studies. Staphylococci in serum required 5 to 10 times (an average of 8) the concentration of this antibiotic which was bacteriostatic for these organisms in serum-free media; 1 to 4 to 1 to 8 dilutions of serum with broth restored the inhibitory action of the drug.

TABLE I.—COMPARATIVE ANTIBIOTIC CULTURE SENSITIVITIES (PER CENT) OF STRAINS OF MICROCOCCUS AUREUS ISOLATED FROM HOSPITALIZED PATIENTS

	Exudate (116 patients)			*Nares (100 patients)*		
	Sensitive	*Partially sensitive*	*Resistant*	*Sensitive*	*Partially sensitive*	*Resistant*
Novobiocin	98.2	0	0.8	99	0	1
Bacitracin	53.5	26.7	19.8	39	26	35
Chloramphenicol	83.5	4.3	12.2	89	2	9
Erythromycin	92.0	1.7	6.3	97	2	1
Penicillin	38.8	2.6	58.6	46	8	46
Streptomycin	70.6	5.2	24.2	87	1	12
Tetracycline	51.7	4.3	44.0	56	9	35

Clinical results. The oral dosage employed in adults was 250 to 500 milligrams every 6, 8, or 12 hours. Fourteen patients received a total daily dosage of 2.0 grams of novobiocin, 30 patients 1.5 grams, and 60 patients received 1.0 gram (or less in infants and very young children). The lower dosage level was adequate for the control of most infections. The duration of treatment ranged between 4 to 6 days for 46 patients and 6 to 35 days for the remaining 58 with an average of 9.5 days. Except for mild diarrhea in 2 patients the drug was well tolerated in the 46 who received novobiocin up to 6 days. In the 58 patients who had treatment in excess of 6 days, generalized pruritic skin rashes with or without fever occurred in 9. Two such reactions occurred on the seventh day of treatment, 4 on the eighth day, 1 on the ninth day, and 2 on the twelfth day of therapy. These rashes usually disappeared within

TABLE II.—COMPARATIVE SENSITIVITIES (PER CENT) OF PENICILLIN AND TETRACYCLINE RESISTANT STRAINS OF MICROCOCCUS AUREUS TO OTHER ANTIBIOTICS

	Penicillin-resistant, 114 strains	*Tetracycline-resistant, 87 strains*
Novobiocin	98.3	97.8
Bacitracin	76.3	79.4
Chloramphenicol	84.2	73.5
Erythromycin	92.1	90.8
Penicillin	—	32.2
Streptomycin	74.5	54.0
Tetracycline	46.5	—

TABLE III.—CLINICAL RESULTS OF NOVOBIOCIN THERAPY

Etiology	*No. of patients*	*Clinical results*		
		Beneficial	*Doubtful*	*Poor*
Infections caused by staphylococci				
Carbuncles and furuncles..	25	20	5	
Cellulitis with abscess.....	22	18	1	3
Breast abscess.....	2	2		
Hydradenitis suppurativa..	3		2	1
Hand infections.....	14	10	3	1
Chronic osteomyelitis.....	2			2
Miscellaneous infections (see test).....	18	8		10
Infections caused by hemolytic streptococci or by hemolytic streptococci and staphylococci.....	20	16	3	1
Totals.....	106	74	14	18

72 to 96 hours following withdrawal of novobiocin and administration of antihistaminics by mouth. Our experience suggests that it is the duration of treatment and not the total daily dosage which is the common denominator.

In Table III are listed the results obtained in the treatment of 106 patients with novobiocin. Inasmuch as most pyogenic surgical infections are necrotizing or potentially necrotizing, the outcome in any group of such lesions is dependent upon a number of factors aside from in vitro sensitivity of the microorganisms and antimicrobial therapy. Since it is difficult to evaluate the role of each factor precisely, the cases have been analyzed by groups on the basis of the important features that play a part in the course of the disease, including the nature, extent, location, and duration of the infection, the presence of complicating factors, antibiotic therapy, and other forms of treatment.

Carbuncles and furuncles (25). Patients harboring these infections were admitted to the hospital for treatment for one or more of the following reasons: treatment failure with penicillin or a tetracycline due to drug-resistant organisms, spread of infection by superimposed trauma such as squeezing of a boil by the patient, the location and extent of the lesions, delayed or inadequate surgical intervention, or inability to institute local rest and immobilization (especially of lower extremities) on an out-patient status. The aims of adjunct novobiocin therapy were to relieve symptoms, encourage rapid resolution of surrounding swelling and inflammation, and to reduce the actual volume of tissue which might undergo necrosis. In patients with multiple furuncles, antibiotic therapy was given for the additional purpose of preventing satellite or recurrent infection. Whenever fluctuation was present but skin necrosis had not yet occurred, incision was made under systemic antibiotic cover, with removal of pus and fibrofatty slough. Lesions already discharging pus spontaneously were treated by rest, dry dressings, and antibiotic therapy. Daily bathing with hexachlorophene-containing soap was instituted in all patients. Response to antibiotic therapy was considered beneficial if cellulitis resolved and discharge of slough and pus, spontaneously or by surgical intervention within 48 to 72 hours, was followed by prompt collapse of the cavity and healing.

Twenty-five patients with furuncles or carbuncles, all due to novobiocin-sensitive organisms were treated with novobiocin for an average of 5.2 days, with limits of 4 to 12 days. One and one-half grams a day for the more severe and 1 gram a day for the milder lesions appeared adequate. Response to therapy was favorable in 20 cases, doubtful in 4, and poor in 1. In the 4 cases in which novobiocin was considered of doubtful benefit, the lesions were already so localizing or localized that resolution of infection could have occurred without adjunct antibiotic treatment. The poor result was in a patient who on arrival presented a large granulating cavity of the buttock following too late evacuation of pus and slough and in whom antibiotic therapy served no useful purpose.

Cellulitis with abscess (22). These inflammations presented as a diffuse, hot tender cellulitis, with or without regional lymphadenitis, some skin necrosis at the portal of entry, and pus under tension. Characteristically, they exhibited less tendency to form a "core" than in furuncles and carbuncles. The portals of entry included punctures by glass or coral, blisters from tight shoes, abrasions,

and a spontaneously ruptured varicose vein of the lower leg in 1 instance. Staphylococci, sensitive in vitro to novobiocin were cultured from each, in connection with secondary infection with nonhemolytic streptococci, Pseudomonas species, or paracolon bacilli in a few instances. Treatment consisted of rest, elevation, novobiocin, surgical drainage as soon as it was reasonably certain that pus was present, and débridement of necrotic skin as well as pockets of pus-laden granulations. There were 22 cases, all in lower extremities. The results of adjunct novobiocin treatment were considered beneficial in 18, equivocal in 1, and poor in 3 cases. One gram of novobiocin in 2 or 4 equal doses for 4 to 8 days appeared adequate in most instances, except for two types of inflammations— those arising from abrasions of the skin of the knee and involving the skin, subcutaneous tissues, and prepatellar bursa and those arising from cuts, particularly by coral, on the plantar surface of the foot. In 3 such cases 1 gram of novobiocin a day for 3 or 4 days in such cases was ineffective as evidenced by uncontrolled infection; supplemental administration of 1 gram by the intravenous route, followed by a 1.5 gram a day dosage schedule was attended by evidence of prompt resolution of cellulitis and localization. These latter patients were given novobiocin for an average of 10 days. The response to novobiocin was considered equivocal in a 59 year old female with a localized draining staphylococcal infection of a hematoma in a ruptured varix of the lower leg; adequate drainage and immobilization were the important factors in elimination of this infection. In 3 other patients novobiocin was considered of no value, because, in 2, the infections were already localized; in the third patient, who had diffuse cellulitis originating in a coral cut distal to the third toe, novobiocin therapy was ineffective, probably due to a combination of inadequate drainage and débridement and possibly too small (1 gm.) a day dosage, and change was made to another antibiotic.

Breast abscess. One of 2 patients developed infection in a lactating breast which had involved both lateral quadrants. Incision and drainage and systemic penicillin failed to control the infection. Studies revealed that the staphylococci were penicillin-resistant but sensitive to chloramphenicol. Chloramphenicol was given for 12 days. On withdrawal of this drug, the pain, erythema, and induration recurred. Novobiocin therapy for 5 days was attended by resolution of the infection. Obviously, drainage was inadequate in this case. The second case occurred in the breast of a nonlactating patient and probably represented a pure staphylococcal infection of the ascending duct. It presented as a diffuse erythema with fluctuation just beyond the areolar rim. Incision and drainage, bedrest, and novobiocin therapy for 5 days culminated in rapid resolution of the infection.

Hydradenitis suppurativa (3). In 1 patient the lesion was opened and curetted under novobiocin protection, without resolution on continued novobiocin therapy. The staphylococci were novobiocin-resistant but sensitive to chloramphenicol, and the lesion became dry and healed following chloramphenicol therapy. Another patient had a draining sinus from which staphylococci and Proteus species, both sensitive to novobiocin, were grown. There was no response to a 5 day course of treatment. Following drainage and curettage the lesions became dry and healed. In the third patient drainage and curettage of an abscessed nodule were effective; however, several neighboring closed nodules were unaffected. Because of the nature of the lesion, antibiotic therapy per se has little, if any, effect on hydradenitis suppurativa.

Hand infections (14). The priniciples of treatment of the various inflammations are the same except for some modification of details for the different types. Novobiocin therapy was given for the purpose of converting spreading to localizing infection and surgical intervention was employed to afford an opportunity to get the antibiotic into the abscess cavity. The lesions were operated upon as soon as there was reasonable assurance that pus was present, and the incisions were

made directly over the point where the pus was judged to be closest to the surface of the skin. All operations were performed in an avascular field to afford the opportunity to explore accurately every ramification of the abscess, to remove obviously necrotic tissue and to avoid accidental trauma to vital structures by the tip of the scalpel. If sloughing of the skin had already occurred no incision was made; the still adherent slough was excised and the underlying cavity cleaned.

A 5 day old, unruptured subcuticular infection of the nail fold of the finger responded promptly to drainage, rest, immobilization, and novobiocin therapy for 4 days. Cultures revealed novobiocin-sensitive staphylococci and novobiocin-resistant alpha hemolytic streptococci. Three patients had digital pulp space infections which had not yet eroded the skin. In 2 of these, 2 hours following a "saturating" dose of 500 milligrams of novobiocin by mouth, incisions were made directly over the fluctuations, pus was released, and necrotic tissues were débrided. Novobiocin was continued in a dosage of 1 gram a day for 5 days. The response in both was rapid, and healing occurred in 7 to 8 days. The third patient sustained infection of the thumb following a burn. In a dispensary, penicillin was given and a hockey-stick incision made. The infection spread. By the time of admission the abscess on the lateral volar aspect of the digit had eroded through the skin. The incised wound was not draining. Cultures revealed penicillin-resistant, novobiocin-sensitive staphylococci and Aerobacter aerogenes. Novobiocin was given for 5 days, with little discernible effect. The patient was seen in consultation at this time and was taken to the operating room, where the fibrofatty slough was débrided, dammed up pus was released, and dirty granulations were wiped away with gauze. The wound healed. Postoperatively, roentgenograms revealed minimal irregularity of the ungual tuft which later disappeared. Novobiocin was continued for 2 weeks. The effects of novobiocin in this case are classed as indeterminate since the same result may have been obtained following adequate drainage. Six patients had infections of the volar creases over the interphalangeal joints with subcutaneous extension to the palm in 5 and to the deep palmar space ("collar-button" abscess) in 1. In 5 of these patients a good response was obtained following novobiocin therapy, incision, drainage, and débridement. The sixth patient had incision and drainage in the web space and tetracycline for 3 days before admission to the hospital. The staphylococci grown from the pus were tetracycline-resistant. The induration resolved slowly after 1 week of novobiocin and local, and might have done so without the benefit of the antibiotic. Four patients had segmental staphylococcal tenosynovitis of the fingers following penetrating wounds in 3 and a spark burn in the fourth. Two responded promptly to incision, débridement, drainage, and 1 week of novobiocin therapy. Recovery of function was complete in 1 patient; there was 15 degrees' limitation of flexion in the other, with complete recovery of function after physical therapy. The infection was present for 2 weeks in the third patient, who had induration of the middle phalangeal area of the finger and a draining sinus. Drainage, immobilization, and novobiocin were instituted. Resolution occurred slowly over the next 9 days. Recovery of function was incomplete, as might be expected. In the fourth patient segmental tenosynovitis followed thermal injury and superinfection; débridement and penicillin were given elsewhere for 7 days before referral to the hospital. The staphylococci were penicillin-sensitive. On admission there was a 2 centimeter necrotic ulcerated area over the middle phalanx on the dorsum of the left finger with minimal cellulitis. Débridement followed by grafting produced a healed wound. There was residual limitation of motion. Novobiocin was of no benefit in this case.

In summary, the effects of novobiocin therapy in 14 staphylococcal infections of the hand were considered favorable in 10, doubtful in 3, and noncontributory in 1.

Chronic osteomyelitis (2). In 1 patient with chronic osteomyelitis recurrence of drainage

was noted 10 days after sequestrectomy and curettage of the involved area in the distal femur. Cultures revealed Staphylococcus aureus, nonhemolytic streptococci, and Staphylococcus albus. Novobiocin was given for 10 days with reduction in the amount of purulent exudate, then was withdrawn because the patient developed a severe allergic dermatitis. Drainage recurred promptly. On reculture the staphylococci now were resistant to 100 micrograms of novobiocin. Another patient had battle-incurred chronic osteomyelitis of the distal third of the femur and numerous metallic foreign bodies in the soft tissues. Cultures revealed staphylococci and nonhemolytic streptococci. There was no discernible therapeutic response to novobiocin for 2 weeks and operation was performed.

Miscellaneous infections (18). A flare-up of staphylococcal cerebritis of the right parietal lobe in a 39 year old patient who had had previous surgical excision of the infected area showed a good and sustained response to 35 days of novobiocin therapy, 2 grams a day. A 36 year old female who developed periesophageal phlegmon of the neck region following "sticking" of a bone spicule 3 days earlier was completely symptom-free after 5 days of oral novobiocin therapy. Oral novobiocin therapy in the amounts of 1 gram a day for 14 days, with drainage, culminated in rapid resolution of a left subdiaphragmatic staphylococcal abscess in a 31 year old female who had had splenectomy for idiopathic thrombocytopenic purpura. One patient with positive Frei test and with tender inguinal lymphadenopathy was considered improved after 10 days of oral novobiocin, 1.5 grams a day. The case of a penile lesion, from which abundant minute gram-negative bacilli, presumably Hemophilus ducreyi—no growth was obtained on culture—with tender fluctuant inguinal nodes showed a good response following 2 aspirations of exudate and 9 days of novobiocin therapy, 1 gram a day. The penile lesion healed and there was only residual induration of the inguinal nodes. There were 3 other cases of pyogenic infections of the inguinal region. One in a 42 year old diabetic was coexistent with numerous pustular lesions over the lower trunk, buttocks, and thigh. Cultures of aspirated exudate revealed novobiocin-sensitive staphylococci. Response to therapy was rapid and extensive tissue breakdown was avoided. A second patient developed suppurative femoral lymphadenitis due to staphylococci and coliform bacilli 6 weeks following repair of a contused laceration of the knee. On admission he was given 1 gram of novobiocin intravenously, and 1 gram by mouth, then taken to the operating room where incision, drainage, and curettage of suppurating lymph nodes and pockets of pus-laden granulation tissue were performed. The wound healed rapidly. The third patient had chronic inguinal suppuration, cause unknown. Cultures revealed staphylococci, Pseudomonas species, and coliform bacilli. After "saturating the patient" with novobiocin, he was taken to the operating room where incision, drainage, and curettage were carried out. In the next few days drainage increased. Examination revealed a deep pocket which was drained; stained smears and cultures later revealed coliform bacilli only which were novobiocin-resistant. Because of culture sensitivities, change was made to streptomycin.

Three patients with infected sebaceous cysts were given novobiocin therapy without discernible response until the contents of the cysts were evacuated. Staphylococci which were resistant to novobiocin were recovered in 1 case; the other 2 were mixed infections. Following surgery, the speed of resolution was no different from that seen in similar cases treated without antibiotics. Four patients had draining sinus tracts. One with seborrheic acne of the neck with multiple draining sinuses from which novobiocin-sensitive Proteus species were cultured showed no response to 3 days' trial of this antibiotic. Incision, drainage, and curettement of intercommunicating sinuses containing stubs of hair effected healing, and novobiocin therapy was considered noncontributory. Another patient had a draining sinus

in the left upper anterior cervical region with moderate cellulitis with fluctuation. Novobiocin was administered for 2 days, with resolution of the cellulitis. The tract was then incised, drained, and curetted, and the findings were compatible with a branchial cleft cyst. The inflammation subsided rapidly, exudation ceased, and novobiocin therapy was considered beneficial. Another patient had a recurrent staphylococcal suppuration from the umbilicus. Novobiocin therapy was given for 48 hours without benefit. Surgical exploration revealed incomplete obliteration of the urachus; there was no connection of the tract with the bladder. The postoperative course was uneventful. It is doubtful whether antibiotic therapy contributed anything to this result. A third patient had a sinus tract in a 2 year old herniorrhaphy scar with purulent drainage due to novobiocin-sensitive staphylococci. Novobiocin therapy for 3 days, as expected, was ineffective. The wound healed following excision of pus-laden granulations around several black silk sutures. Prior to complete healing the staphylococci grown on repeat culture were resistant in vitro to 100 micrograms of novobiocin. Finally, there were 3 patients with infections along the nail of the big toe, occasioned by pressure of tight shoes. Staphylococci and coliform bacilli were cultured in each instance. These responded to rest, elevation of the nail, and curettage of dirty granulations. Novobiocin therapy was considered noncontributory.

Hemolytic streptococcic infections (10). All 10 of these patients had disseminated acute inflammations of the extremities with lymphangitis, including 1 case of diffuse tenosynovitis of the finger. On 1.0 or 1.5 grams of daily novobiocin therapy, resolution occurred in 9 of 10 patients after 4 to 6 days of treatment. Whether or not the 1 treatment failure—a diffuse cellulitis of the leg—was due to novobiocin-resistant hemolytic streptococci could not be established because of lack of exudate for culture. The impression was gained that response of these cellulitides to novobiocin was less uniformly dramatic than to the older antibiotics.

Hemolytic streptococcal and staphylococcal infections (10). Not all cases of spreading cellulitis are due to hemolytic streptococci alone, nor are all localizing inflammations due to staphylococci. We treated 10 patients with novobiocin who had open staphylococcal infections of extremities coexistent with ascending hemolytic streptococcal cellulitis with beneficial results in 7 and equivocal results in 3. The cellulitides responded to rest and novobiocin, but drainage was required for release of pus following localization. The 3 equivocal results were in patients in whom either drainage of a purulent focus was delayed and probably inadequate, or whose infection was already localizing when novobiocin therapy was instituted.

DISCUSSION

Our studies reaffirm that novobiocin possesses a high degree of activity against staphylococci isolated from hospitalized patients. All but 3 of 216 strains of the strains tested were susceptible in vitro to this antibiotic; the 3 resistant strains were recovered from patients without previous contact with novobiocin, suggesting that native strains which are resistant to it do exist. Emergence of novobiocin-resistant staphylococci in 2 unhealed, chronic infections was noted, and similar observations have been reported by Kirby and associates and by Nichols and Finland. According to prevailing opinion, the emergence of resistant staphylococci parallels the frequency with which antibiotics are employed. We are concerned lest the unrestricted use of novobiocin should eventually follow the same pattern of the older antibiotics. Penicillin and tetracycline, the two most widely used systemic, and bacitracin, the most widely used local, antibiotic on our surgical wards and in the military dispensaries served by our hospital, are now among the least uniformly effective antistaphylococcal drugs. We have noted no therapeutic advantages accruing from the high serum concentrations of novobiocin which attend the administration of 1 gram or more daily to adults, and, we assume that the 5 to 10 times

higher concentrations of this drug required to inhibit growth of staphylococci in serum as compared to serum-free media, nullify this advantage.

In addition to the potentialities of emergence of resistant staphylococci in novobiocin-treated patients, another factor which indicates the need for special care in the selection of patients for novobiocin therapy is the occurrence of allergic dermatitis in some patients requiring a course of novobiocin therapy for more than 6 days. The incidence of these reactions in our series of cases is in contrast to that reported by Welch, who noted only 1 rash in 208 volunteers given 1 gram of novobiocin for 12 days, and that of Rutenburg and associates who reported no reactions attending clinical trials of the cathomycin form of novobiocin in 90 surgical patients.

The therapeutic results of our clinical trials of novobiocin in pyogenic surgical infections were, in general, favorable, and the responses were reminiscent of those observed previously in evaluating similar groups of patients treated with erythromycin and with tetracycline. Pyogenic infections were most responsive if treated when still in the early acute, or cellulitic phase. If treatment was instituted only after pus had already formed, the character of the response was conditioned by the promptness and precision with which surgical intervention was carried out. When surgery was performed as soon as it was reasonably certain that pus was present, and the skin was still not so damaged that it was incapable of recovery, the period of disability was shortened. We have recounted the habits of different clinicians as regards the time at which incision was used to drain pus: too early, as in the case cited of a "hockey-stick" incision for digital pulp space infection before pus formed, or too late, as in the instances of applying hot soaks until cellulitis resolved and the abscess eroded through the skin. Even when the infection had progressed to the stage of skin necrosis, removal of pus and necrotic slough under antibiotic cover still effected improvement in results. Prompt surgical intervention allowed blood-borne novobiocin to clear away residual areas of infection and healing in a matter of days. Blind reliance on antibiotic therapy and unnecessary delay in surgical intervention culminated in wastage of drug and unnecessary delay in healing. When a clean granulating cavity obtains, antibiotics do not contribute to overcoming the mechanical factors which govern healing, and continued administration of these drugs serves no useful purpose. Finally, in chronic infections, novobiocin, like the older antibiotics, was ineffective.

Novobiocin therapy in closed (hemolytic streptococcal) inflammations of soft tissues afforded no advantages over the older antistreptococcal antibiotics. We are in agreement with Kirby and associates who recommend that "novobiocin be used exclusively for the treatment of infections caused by antibiotic-resistant staphylococci."

SUMMARY

Novobiocin, a new antibiotic, has been studied in the laboratory, and in the treatment of a large variety of pyogenic surgical infections in 106 patients.

Novobiocin was found to be highly active in vitro on all but 3 of 216 strains of staphylococci of human origin, and on the majority of other gram-positive cocci; conversely, it was found to be relatively ineffective on most gram-negative bacilli. The in vitro activity on staphylococci is depressed markedly in the presence of serum, 5 to 10 times the amount of drug being required over the concentration which is bacteriostatic in serum-free culture media.

Novobiocin by mouth in divided daily doses of 1.0, 1.5, or 2.0 grams daily was well tolerated in 48 of the 106 patients who received this drug for 6 days or less. In 58 others who had treatment for longer periods of time, 9 developed generalized pruritic maculopapular rashes which disappeared following cessation of therapy. Divided daily doses of 1.5 grams for the more severe, and daily doses of 1.0 gram for the milder infections appeared adequate.

Results in these 106 patients with various clinical infections were favorable in 74 per cent of the cases, and the nature of the responses was comparable to that obtained with the older antibiotics. In 2 indolent staphylococcal infections in which healing did not occur, emergence of novobiocin-resistant organisms was observed. The impression was gained that the resolution of novobiocin-treated hemolytic streptococcal infections was no more rapid than with the older antibiotics. The reservation of novobiocin for use solely in staphylococcal infections due to organisms resistant to other antibiotics seems warranted.

REFERENCES

1. Hoeksema, H. Caron, L. E., and Hinman, J. W. Novobiocin. J. Am. Chem. Soc., 1956, 78: 2019–2020.
2. Kirby, Wm. M., Hudson, D. G., and Noyes, W. D. Clinical and laboratory studies of novobiocin, a new antibiotic. Arch. Int. M., 1956, 98: 1–7.
3. Nichols, R. L., and Finland, M. Novobiocin, a limited bacteriologic and clinical study in 45 patients. Antibiot. M. & Clin. Ther., 1956, 2: 241–257.
4. Pulaski, E. J., and Beatty, G. L. Tetracycline therapy of surgical infections. Surg. Gyn. Obst., 1956, 102: 9–17.
5. Pulaski, E. J., and Wesolowski, S. A. The use of erythromycin in certain surgical infections. Surg. Gyn. Obst., 1954, 98: 55–61.
6. Rutenburg, A. M., Shapiro, P., and Schweinburg, F. Novobiocin in the treatment of surgical infections due to staphylococci and other gram-positive bacteria. N. England J. M., 1956, 255: 325–330.
7. Welch, H., Lewis, C. N., Putnam, L. E., and Randale, W. A. A study of sensitizing potential of novobiocin. Antibiot. M. & Clin. Ther., 1956, 3: 27–32.

RETROGRADE PERFUSION OF THE CORONARY SINUS FOR DIRECT VISION AORTIC SURGERY

VINCENT L. GOTT, M.D., JUAN L. GONZALEZ, M.D., MOHAMED NAZIH ZUHDI, M.D., RICHARD L. VARCO, M.D., F.A.C.S., and C. WALTON LILLEHEI, M.D.,

Minneapolis, Minnesota

IN THIS CLINIC, the development and application of practical and effective techniques for total cardiopulmonary by-pass has permitted many successful intracardiac operations on the right side of the heart and for a variety of lesions. Similar direct vision reparative procedures upon the aortic valve or ascending aorta have remained a challenge because of the problems of myocardial support and coronary air embolism.

By using concomitantly the pump-oxygenator to maintain systemic circulation during total by-pass of the heart and lungs and a separate cannula in the coronary sinus to back perfuse arterial blood through the coronary venous system, it has been possible to open the ascending aorta and work successfully in man (13) on the aortic valve for periods of 15 to 20 minutes by utilizing techniques developed in the experimental studies herein reported.

Pratt in 1898 first suggested the possibility of nourishing the myocardium via the thebesian and coronary veins. Using an extirpated cat's heart he cannulated the pulmonary artery, occluded all the openings of the right side of the heart and filled the cannula "to a height of several inches" with arterial blood. He stated that these extirpated hearts beat for several hours, that no blood was seen egressing from the coronary arteries, and suggested that there was an in and out ebbing of the blood into the thebesian and coronary veins. Roberts, in 1943, and Beck (1, 3), in 1948, demonstrated in the dog that arterialization of the coronary sinus improved somewhat the mortality rate of major coronary artery ligation. Blanco and his associates have carried out studies upon the use of the back perfusion concept to visualize the aortic valve in dogs.

Anatomically in the dog, the coronary sinus drains venous blood from the left ventricle and the posterior aspect of the ventricular septum. The right ventricle is drained by the anterior cardiac veins which empty directly into the right atrium by separate orifices. Approximately one-third of all human hearts have a drainage pattern similar to that of the dog. Another one-third demonstrate almost complete drainage of the right ventricular coronary blood into the coronary sinus by way of the vena cordis parva. In the remaining group, a lesser portion of the right ventricular myocardium is drained by the coronary sinus. Despite the fact that virtually no retroperfusion of the right ventricle takes place from the coronary sinus in the dog, the canine heart appears to tolerate 15 to 20 minutes of reduced blood flow to the right ventricle rather well, particularly when the cardiac work load has been markedly reduced by total by-pass and the left ventricle remains well oxygenated. In man the more favorable anatomic pattern of the coronary veins usually permits a more adequate retroperfusion of the right side of the heart as well as the left ventricle from the coronary sinus.

From The Department of Surgery, University of Minnesota Hospitals and Variety Club Heart Hospital, Minneapolis.

Supported by research grants from: Eddie Bekins Research Fund, Graduate School, University of Minnesota, Minnesota Heart Association, American Heart Association, Life Insurance Medical Research Foundation, National Heart Institute (Grant No. H-830), and Minnesota Cardiovascular Fund.

METHODS AND MATERIALS

Forty-five dogs have been utilized in these experiments. Fifteen animals were used in acute experiments to study forward and backward coronary flows, quantitating and correlating flow rates, perfusion pressures, electrocardiograms, gross appearance of the heart, and myocardial oxygen consumption. During these studies the animal's heart and lungs were totally by-passed and the circulation supported by the pump-oxygenator. The results of an additional 20 back perfusion studies, with survival the objective, are also presented.

The dogs, weighing from 15 to 23 kilograms, were anesthetized with 2½ per cent pentothal sodium and placed on a cam-type respirator utilizing compressed air. A pump-oxygenator (6, 14) was used to maintain the circulation while the heart and lungs were by-passed. Each animal's body temperature was monitored and external heat supplied, as required, to keep it at a normal value. The maintenance of the animal's normal temperature during the by-pass procedure was effected by having the oxygenator helix-reservoir immersed in a waterbath thermostatically maintained at 41 degrees C. and by an electric heating pad placed under the animal's body.

The coronary sinus was perfused with oxygenated blood. This blood was secured either through a Y connector from the main arterial (efferent) limb of the oxygenator or pumped from the arterial reservoir of the oxygenator by a separate pump. The former method is simpler, and the quantity of blood perfusing the coronary veins was readily regulated by an adjustable clamp on the limb leading to the coronary sinus. With this method, the pressure in the coronary sinus was monitored continuously and the adjustable clamp regulated to keep this pressure at a predetermined level. In this way, too, an excessive perfusion pressure can be avoided.

In the experimental laboratory a ridged nylon tip, 6 millimeters in diameter and 2 centimeters long attached to a plastic catheter, has been most satisfactory for cannulation of the sinus. This tip is then anchored in the coronary sinus orifice by an encircling silk ligature.

After a right thoracotomy and wide incision of the pericardium, the coronary sinus is readily exposed. Because of excellent external landmarks in the dog the coronary sinus ostium can be easily cannulated without actually visualizing it. In these studies some cannulations were done by open right atriotomy, but most were carried out blindly through a purse-stringed aperture in the right atrium. Once the cannulation tip is in place it can be secured by a silk suture inserted from outside of the heart. It appears preferable to introduce the needle into the dimple at the junction of the inferior vena cava and coronary sinus and direct it so as to pass around the catheter and out the right ventricular myocardium proximal to the posterior middle cardiac vein. This ligature is then tightened onto the catheter tip ridge as the latter is pulled up against it. This method of insertion facilitates perfusion of the posterior middle cardiac vein, which normally drains the posterior ventricular septum and which enters the coronary sinus very close to its orifice. When the closed technique of cannulation was employed, another catheter was usually placed through the right auricular appendage and into the right ventricle to aspirate the thebesian flow into that area.

Normal coronary sinus venous blood flows were determined in both by-passed and non-by-passed hearts. The volume flowing from a cannula in the coronary sinus was measured per minute. The thebesian return in the by-passed heart was aspirated from the right side of the heart for 1 minute and measured while the coronary sinus catheter was in place and the pulmonary artery was occluded. Also, the flow from the left coronary artery ostia during retrograde perfusion was measured in the by-passed heart through an aortotomy either by cannulating the left coronary artery orifice directly or by collecting with the suction tip the blood seeping into

TABLE I.—BLOOD FLOW FROM THE CORONARY SINUS IN THE NORMAL WORKING HEART AND IN THE NONWORKING (BUT BEATING) BY-PASSED HEART

			By-passed heart				
Dog No.	*Wt. in kilo.*	*Normal coronary sinus flow, c.c./min.*	*Pump flow, c.c./min.*	*Cor. sin. flow, c.c./min.*	*Thebes. flow, c.c./min.*	*Total, c.c./min.*	*Per cent of pump flow*
1553	19.5	62	600	50	46	96	16.0
1438	17.4	40	600	44	20	64	10.7
1320	15.1	40	530	40	30	70	13.2
1769	18.4	38	600	40	25	65	10.8
1758	19.6	60	650	64	32	96	14.7
1944	18.4	54	600	60	36	96	16.0
116	18.4	36	650	48	30	78	12.0
271	20.3	46	700	60	30	90	12.8
383	19.0	46	650	60	40	100	15.4
401	17.2	52	600	45	15	60	10.0
539	18.2	40	630	40	20	60	9.5
489	16.6	39	580	40	22	62	10.7
543	18.4	40	600	42	21	63	10.5
683	20.5	56	700	56	30	86	12.4
675	17.8	34	600	44	33	77	12.8
						Average	12.5

the corresponding cusp. Under these conditions in the dog, retrograde flow from the right coronary artery was either absent or negligible.

Oxygen content as well as the lactate and glucose levels were determined in the blood collected from the coronary artery and veins in the by-passed and retrogradely perfused hearts.

Electrocardiograms were recorded during all experiments.

RESULTS

Blood flow from the coronary sinus in the normal heart and in the nonworking by-passed heart. In order to determine the approximate, and the optimum, flow to be utilized during retrograde perfusion of the coronary sinus, the volume normally escaping through the coronary sinus was measured in 15 acute experiments among both by-passed and non-by-passed hearts. The approximate quantity of the thebesian return was also determined in the by-passed heart. These data are presented in Table I. In all but 2 instances the coronary sinus flow was higher in the by-passed heart than in the non-by-passed heart despite the fact that the pump-oxygenator flow into the aorta in the former instance was approximately one-third of the estimated normal cardiac output. This circumstance could be due to a failure to ligate securely the collecting catheter in the coronary sinus in the case of the animals with a non-by-passed heart. However, the catheter tip was large enough to permit a snug fit in the coronary sinus. Moreover, a more likely alternative explanation of this observed increase in coronary flow is the fact that the resistance to blood flow in the coronary bed decreases substantially when the heart is by-passed (17).

In these acute experiments, the thebesian return to the right side of the heart, during by-pass, approximated 50 per cent of the coronary sinus return, and the average value for the total coronary sinus return to the right side of the heart was 12.5 per cent of the volume of blood pumped mechanically.

Retrograde perfusion of coronary sinus. Figure 1 presents data from retrograde coronary sinus perfusion studies in which the flow rate was increased from 25 cubic centimeters per minute to 55 cubic centimeters per minute. During this increase, disproportionately more blood was shunted from the coronary sinus into the right side of the heart through thebesian channels. The flow uniformly, per unit time, from the left coronary artery ostia did not increase proportionately with the greater perfusion pressure. The synchronized electrocardiogram reveals that the highest pressure in the coronary sinus and the cathe-

Retrograde Flow	25 cc/ min.	35 cc/ min.	45 cc/ min.	55 cc/ min.
Flow From Left Coronary Artery Ostia	12 cc/ min.	12 cc/ min.	14 cc/ min.	16 cc/ min.
Thebesian Flow Into Rt. Heart	10 cc/ min.	18 cc/ min.	25 cc/ min.	33 cc/ min.

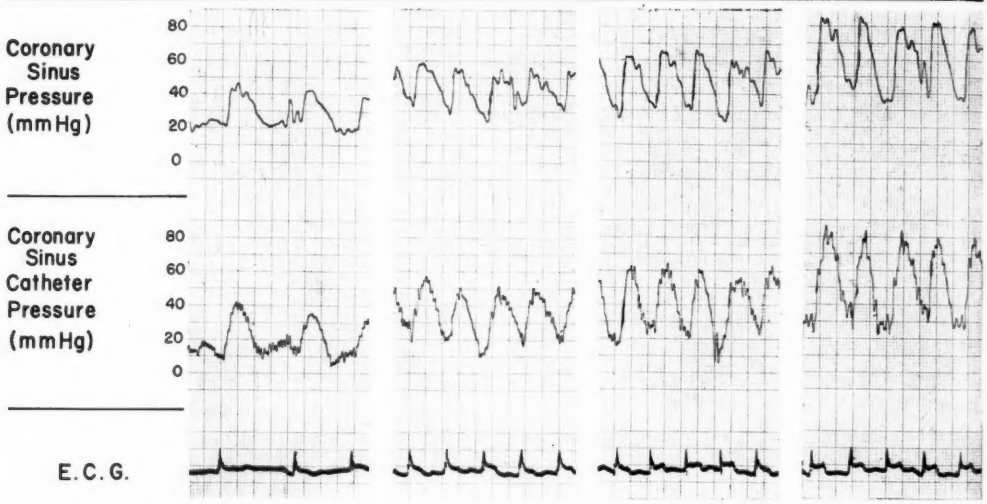


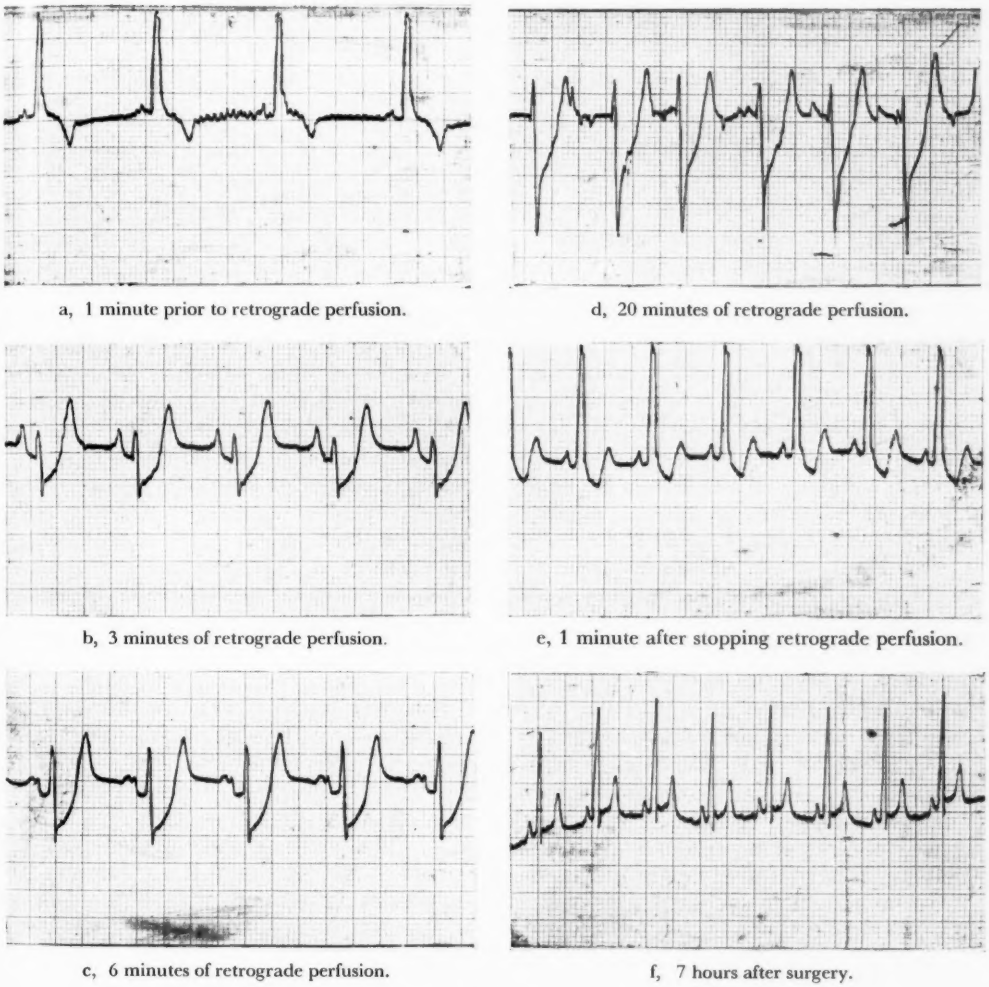
FIG. 1. Typical coronary sinus pressures and distribution of retrograde flow. Dog 683, weight 20.5 kilograms, normal coronary sinus flow 62 cubic centimeters per minute, thebesian flow 30 cubic centimeters per minute.

ter coincide with the ventricular systole, quite as one would expect.

Electrocardiographic changes. The electrocardiographic changes in Figure 1 are somewhat more marked than those usually found for this was an acute study which necessitated retrograde perfusion for more than an hour. The usual electrocardiographic changes, secondary to retrograde coronary sinus perfusion for briefer periods, are reproduced in Figure 2. Lead II has customarily been used. Soon after beginning the retrograde coronary sinus perfusion a depression of the S-T segment appears, the T wave deflection reverses, and the height of the R wave is reduced.

This pattern perhaps reflects the reduction in circulation to the myocardium of the right ventricle in the heart being retrogradely perfused since it is known from the anatomic observations, already mentioned, that this portion of the dog's heart is not, or at best is minimally, perfused via blood introduced into the coronary sinus.

Upon termination of a less lengthy retrograde perfusion, the electrocardiogram promptly, within minutes, reverts almost completely to normal. A late electrocardiographic residual of the retrograde perfusion discerned in some animals has been a T wave reversal persisting for several days. Heart block, even first degree, was rarely seen.



a, 1 minute prior to retrograde perfusion.

d, 20 minutes of retrograde perfusion.

b, 3 minutes of retrograde perfusion.

e, 1 minute after stopping retrograde perfusion.

c, 6 minutes of retrograde perfusion.

f, 7 hours after surgery.

FIG. 2. Representative electrocardiographic changes during retrograde perfusion of the coronary sinus.

Metabolic observations. In 10 of these experiments data were compiled on the myocardial consumption of oxygen, glucose, and lactate during the by-passed state and with the heart retrogradely perfused. The mean values for these determinations are summarized in Table II. A study of these values indicates unequivocally that oxygen utilization occurs from the blood circulated retrogradely.

The oxygen consumption appears to be less during retrograde perfusion than when the by-passed heart received its blood flow normally. This observation may be explicable in part upon the basis of the minimal blood flows utilized during retrograde perfusion to prevent venous congestion and ecchymosis.

It is apparent from the data in Table II that the by-passed heart consumed lactate

TABLE II.—METABOLIC VALUES* IN 10 EXPERIMENTS

	—*By-passed heart with normal coronary circulation*—				—*By-passed heart with retrograde perfusion via the coronary sinus*† —			
	Sys. art.	*Cor. vein*	*A.V. diff.*	*Consump. per 100 gm. left ventricle per min.*	*Cor. vein*	*Left cor. art. ostium*	*A.V. diff.*	*Consump. per 100 gm. left ventricle per min.*
Oxygen (vols. per cent)	20.5	5.1	15.4	11.4 c.c.	20.9	4.4	16.5	3.6 c.c.
Glucose (mgm. per cent)	92.0	88.0	4.0	2.4 mgm.	120.0	88.0	32.0	7.4 mgm.
Lactate (mgm. per cent)	29.3	25.1	4.2	3.1 mgm.	45.2	55.3	+10.1	Produced 2.1 mgm. per 100 gm. per min.

*Mean.
†Arch of aorta cross clamped and proximal ascending aorta opened during 15 minutes of retrograde perfusion together with systemic perfusion of the animal via the pump-oxygenator.

but took up relatively little glucose. However, in the myocardium perfusion via the coronary sinus the consumption of glucose was increased over the normal and more lactic acid was produced than consumed.

Protection offered by retrograde perfusion. The results of the last survival type experiments are listed in Table III. In all cases the heart action was good during retrograde perfusion via the coronary sinus. Four of 16 dogs undergoing retrograde perfusion for 15 to 20 minutes exhibited ventricular fibrillation. In each instance this arrhythmia appeared after the perfusion had been terminated and coronary artery flow via the aorta had been reinitiated. In all but 1 of these cases the heart defibrillated with a single shock and without additional complication. Conceivably, this fibrillary episode was comparable to Beck's (2) proposed trigger mechanism.[1] Although specifically searched for, coronary air embolism was not recognized as a cause of fibrillation in these 4 animals.

Three of the 4 dogs submitted to 30 minute retrograde perfusion died. Only 1 death occurred from cardiac causes after a retroperfusion of 15 to 20 minutes. This animal (No. 1760) was operated upon prior to our routinely monitoring the pressures developed in the coronary sinus during retrograde perfusion. This dog, weighing 16 kilograms, was perfused at the rate of 40 cubic centimeters per minute and developed severe myocardial ecchymosis as revealed at autopsy some 4 hours after operation.

Dogs in a control series were subjected to total myocardial ischemia for 15 minutes while the heart was by-passed. All developed ventricular fibrillation and only 1 animal survived (90 per cent mortality). This high mortality and universal fibrillation was substantially reduced in the group of animals similarly by-passed but with support of the myocardium for 15 to 20 minutes by retrograde perfusion via the coronary sinus (Table III). In this later series the incidence of fibrillation was 25 per cent and the total mortality was 25 per cent, and each of these 4 deaths appeared to be due to controllable errors in technique.

[1]The fibrillation may be explained by the fact that the ischemic right ventricle is suddenly perfused with oxygenated blood.

DISCUSSION

Normally 4 to 5 per cent of the cardiac output is said to be directed into the coronary arteries. However, apparently when the heart is by-passed, the volume of coronary circulation remains unchanged or may increase despite a lower blood pressure and with a reduced systemic flow (17). This relatively high volume of coronary flow in the by-passed heart indicates reduced resistance in the coronary bed, and this may derive in turn from the reduced resistance against which the heart contracts when empty. With the myocardium flaccid and contracting only against air, blood flow through the myocardial capillaries can occur at a much lower resistance and thus continuously throughout both systole and diastole. This protective mechanism appears to function in man as observed during a number of intracardiac operations in which the development of ventricular fibrillation during the by-pass has been very unusual.

Monitoring the pressures in the coronary sinus during retroperfusion seems to be an

TABLE III.—SUPPORT OF THE MYOCARDIUM BY RETROGRADE PERFUSION OF ARTERIALIZED BLOOD VIA CORONARY SINUS (OPERATIONS FOR SURVIVAL)

Dog No.	*Perfusion time, mins.*	*Heart action*	*Fib.*	*Mort.*	*Comment*
1310	15	Good, 1° heart block	0		
1589	15	Excellent	0	+	Pentothal added during perfusion. Respiratory death 3 hours postoperatively
1823	15	Excellent	0	+	Death 7 hours postoperatively from dissecting aneurysm arising at aortotomy site
1760	15	Poor, ectopic ventricular beats	+	+	Too high retrograde flow with venous distention and echymoses. Death 4 hours postoperatively
387	15	Excellent	0		
419	15	Good	+		Fibrillated on stopping retrograde perfusion. Defibrillated with single shock
389	15	Good	0		
431	15	Excellent	0		
478	15	Excellent	0		
255	15	Excellent	0	+	Death 2 days postoperatively with severe distemper and pneumonia
992	15	Good	0		
941	15	Good	0		
1371	20	Good	0		
385	20	Excellent	0		
431	20	Excellent	+		Heart action excellent during perfusion, fibrillated on stopping. Defibrillated with 1 shock
1019	20	Good, 1° heart block	+		Heart action excellent during perfusion, fibrillated on stopping. Defibrillated with 1 shock
1634	30	Excellent	0		
635	30	Good	+	+	Heart action good during retrograde perfusion. Fibrillated on stopping retrograde perfusion. Unable to defibrillate
1141	30	Good	+	+	Heart action good during retrograde perfusion. Fibrillated on stopping retrograde perfusion. Unable to defibrillate
202	30	Good	+	+	Heart action good during retrograde perfusion. Fibrillated on stopping retrograde perfusion. Unable to defibrillate

important precaution. If coronary sinus pressure rises much above 60 millimeters of mercury systolic or above a mean of 40 millimeters of mercury, areas of ecchymoses appear in most instances. Although a few canine hearts tolerated higher coronary vein pressures without apparent injury, this reaction was unpredictable. When the coronary sinus pressure is allowed to reach 80 millimeters of mercury for several minutes, visible damage was the rule. Originally, in these studies we estimated a proposed retrograde flow rate on the basis of the animal's total body weight. This practice proved unsatisfactory. We observed a great variation in the coronary sinus pressures for the same flow rate in various hearts ultimately demonstrated to be of approximately the same weight. It is apparent that the number of coronary sinus-thebesian shunts varies from dog to dog, seemingly unrelated to heart size, and may more likely be a species and age characteristic. For this reason, we found that routinely monitoring the pressure in the coronary sinus catheter and regulating the flow accordingly was superior to use of a predetermined flow rate. For retrograde perfusion the optimum mean pressure in the perfusing catheter appears, from the available data, to be 30 millimeters of mercury.

TABLE IV.—RESULTS IN 10 DOGS HAVING 15 MINUTES OF MYOCARDIAL ISCHEMIA AND TOTAL HEART BY-PASS (CONTROL SERIES)

Dog No.	*Ventricular fibrillation*	*Comments*
1317	+	Died 4 hrs. P.O.
1399	+	Died 6 hrs. P.O.
1045	+	Died 2 hrs. P.O.
1289	+	Died 12 hrs. P.O.
268	+	Died 1 hr. P.O.
202	+	Died 4 hrs. P.O.
341	+	Died 18 hrs. P.O.
481	+	Died 24 hrs. P.O.
1809	+	Survived

The retrograde flow emerging from the left coronary artery ostium, though not voluminous, is apparently sufficient for the canine myocardium for periods of 15 to 20 minutes when the work load is very low. On the other hand, similar periods of ischemia with by-pass and without retrograde perfusion are almost uniformly fatal (Table IV).

The increasing cyanosis of the right heart appears to be a limiting factor in retrograde perfusions lasting longer than 20 minutes. We are, therefore, studying the possibility of retrograde perfusion in combination with cardiac asystole induced by potassium citrate or prostigmine as a means of temporarily reducing still further the myocardial requirements. In utilizing potassium citrate asystole alone, as suggested by Melrose, the animal's myocardium has appeared flaccid and cyanotic after 15 minutes of arrest. Many of these dogs have died within 8 postoperative hours (7). When potassium citrate induced asystole and retrograde perfusion in dogs were combined the results have been considerably better (7).

CLINICAL EXPERIENCE

Seven patients have been operated upon by using retrograde perfusion of the coronary sinus together with total by-pass of the heart and lungs by means of a pump and bubble type oxygenator. These cases are summarized as follows:

CASE 1. M. J., a 39 year old woman, had this type of retrograde perfusion for 14 minutes during which time the ascending aorta was opened and a heavily calcified and severely stenotic aortic valve was incised under direct vision. This first patient (13) was operated upon January 31, 1956 and is doing very well at this time 1 year postoperatively.

CASE 2. C. H., a 52 year old woman, had a combination of predominantly rheumatic aortic regurgitation with moderate aortic stenosis and mitral stenosis as well. On May 23, 1956 the aortic valve was remodeled under direct vision through an aortotomy. Retrograde perfusion was utilized for 13 minutes, and she is well at this time. This patient also underwent a concomitant direct vision mitral commissurotomy through a left atriotomy. She is greatly improved postoperatively.

CASE 3. W. M., a 24 year old man, had a subvalvular aortic stenosis of congenital origin successfully excised on July 20, 1956 during 10 minutes of retrograde perfusion with total cardiopulmonary by-pass. The pressure gradient of 110 millimeters of mercury across the aortic valve was completely eradicated and since this patient's aortic leaflets were normal it is believed a curative result has been obtained in this patient.

CASE 4. J. H., a 28 year old man with acquired calcific aortic stenosis, succumbed 2 days postoperatively after a direct attack on the lesion. Death apparently resulted from aortic insufficiency. The duration of the retrograde perfusion was 14 minutes.

CASE 5. D. D., a 10 year old girl, had a sinus of Valsalva rupture into the right ventricle. This condition was corrected on May 2, 1956 through an open right ventriculotomy during 10 minutes of retrograde coronary perfusion. The proximal aorta was cross clamped to achieve a dry operative field. Her pulse pressure is now normal, and she appears to be completely cured.

CASE 6. T. A., a 2 year old boy, weighing 7 kilograms, had complete transposition of the great vessels. On May 31, 1956 during a 1 hour and 11 minute heart lung by-pass with the pump-oxygenator the great vessels were transplanted. The aorta was transposed to the posterior (left) ventricle together with its coronary arteries and aortic valve. Retrograde perfusion was utilized for 16 minutes to permit this aspect of the procedure. The heart action was excellent during the by-pass and at the conclusion of the operation, but the patient succumbed later in the postoperative interval. Autopsy failed to disclose an anatomic reason for death.

CASE 7. A. F., a 7 month old girl, weighing 5.7 kilograms, had an aorticopulmonary window divided and the fistulous openings oversewn on April 13, 1956 by use of a total cardiopulmonary by-pass and retrograde perfusion through the coronary sinus for 9 minutes and 40 seconds. The child died 10 days postoperatively from respiratory complications. Postmortem examination showed a complete correction of the septal defect together with a diffuse bronchiolitis obliterans and widespread severe subintimal pulmonary arteriolar proliferation. Undoubtedly, this child's severe pulmonary hypertension and occlusive arteriolar lesions were a major contribution to her death.

In each of these clinical patients the retrograde perfusion maintained the heart well and free of development of any arrhythmias. In the 1 instance that the heart beat became weaker than usual, the color of the myocardium remained very good (W. M.). Subsequently, an error was found in the polyviso recording technique so that the coronary sinus perfusion was carried out at a pressure of only 10 millimeters of mercury during that period whereas preferably the pressure should have been 30 millimeters of mercury. Despite this fact, the patient's heart took over immediately when the reparative surgery had been completed. There was no arrhythmia, and a normal systemic pressure was soon established.

It appears from these observations that human hearts tolerate prolonged retrograde perfusion better than the canine hearts. This fact is understandable and even predictable upon the basis of the more favorable venous drainage pattern from both ventricles into the coronary sinus in man; thus the right ventricle is permitted to be perfused to some extent as well as the left ventricle from the arterialized blood introduced into the coronary sinus.

CONCLUSIONS

1. Retrograde perfusion, via the coronary sinus, of oxygenated blood, in combination with a pump-oxygenator permits work on the open ascending aorta or coronary arteries for periods of up to 20 minutes in the dog.

2. Flow studies of the coronary sinus venous drainage demonstrate in most instances a higher coronary flow in the by-passed heart even though the perfusion pressure in the aorta remains lower than for the non-bypassed heart.

3. In 15 acute experiments the distribution (chamber-wise) of the retrograde perfusate has been studied. Also the coronary arteriovenous differences were determined for oxygen, glucose, and lactate.

4. Twenty dogs were perfused seeking a survival experiment in each. Their hearts tolerated well 15 to 20 minutes of retrograde perfusion if the head of pressure was adjusted properly.

5. The method of back perfusion via the coronary sinus has been tested in 7 clinical cases to date. In all instances, the method appeared to protect the myocardium well against anoxia and coronary air embolism permitting direct vision reparative surgery for aortic stenosis and regurgitation, ruptured sinus of Valsalva, aortic-pulmonary septal defect, and complete transposition of the great vessels. The human heart responded well to this altered environment for periods up to 15 minutes.

REFERENCES

1. BECK, C. S. Revascularization of the heart. Ann. Surg., 1948, 128: 854.
2. BECK, C. S., and LEIGHNINGER, D. S Scientific basis for surgical treatment of coronary artery disease. J. Am. M. Ass., 1956, 159: 126.
3. BECK, C. S., STANTON, E., BATIUCHOK, W., and LEITER, E. Revascularization of the heart by a graft of systemic artery into coronary sinus. J. Am. M. Ass., 1948, 137: 436.
4. BLANCO, G., ADAM, A., and FERNANDEZ, A. A direct experimental approach to the aortic valve—II, acute retroperfusion of the coronary sinus. J. Thorac. Surg., 1956, 32: 171.
5. CAMPBELL, G. S., CRISP, N. W., and BROWN, E. B., JR. Total cardiac by-pass in humans utilizing a pump and heterologous lung oxygenator (dog lungs). Surgery, 1956, 40: 364–371.
6. DEWALL, R. A., WARDEN, H. E., READ, R. C., GOTT, V. L., ZIEGLER, N. R., VARCO, R. L., and LILLEHEI, C. W. A simple, expendable, artificial oxygenator for open heart surgery. Surg. Clin. N. America, 1956, 36: 1–10.
7. GOTT, V. L., GONZALEZ, J. L., PANETH, M., VARCO, R. L., and LILLEHEI, C. W. Retrograde perfusion of the coronary veins with and without induced asytole for open operative procedures upon the aortic valve or the coronary arteries. Proc. Soc. Exp. Biol., N.Y., in press.
8. LILLEHEI, C. W. Controlled cross circulation for direct-vision intracardiac surgery; correction of ventricular septal defects, atrioventricularis communis, and tetralogy of Fallot. Postgrad. M., 1955, 17: 388–396.
9. LILLEHEI, C. W., COHEN, M., WARDEN, H. E., READ, R. C., AUST, J. B., DEWALL, R. A., and VARCO, R. L. Direct vision intracardiac surgical correction of the tetralogy of Fallot, pentalogy of Fallot, and pulmonary atresia defects; report of first ten cases. Ann. Surg., 1955, 142: 418–445.
10. LILLEHEI, C. W., COHEN, M., WARDEN, H. E., READ, R. C., DEWALL, R. A., AUST, J. B., and VARCO, R. L. Direct vision intracardiac surgery by means of controlled cross circulation or continuous arterial reservoir perfusion for correction of ventricular septal defects, atrioventricularis communis, isolated infundibular pulmonic stenosis, and tetralogy of Fallot. Pp. 371–392. Henry Ford Hospital, International Symposium on Cardiovascular Surgery. Philadelphia: W. B. Saunders Co., 1955.

11. Lillehei, C. W., Cohen, M., Warden, H. E., and Varco, R. L. The direct-vision intracardiac correction of congenital anomalies by controlled cross circulation; results in thirty-two patients with ventricular septal defects, tetralogy of Fallot, and atrioventricularis communis defects. Surgery, 1955, 38: 11–29.
12. Lillehei, C. W., Cohen, M., Warden, H. E., Ziegler, N. R., and Varco, R. L. The results of direct vision closure of ventricular septal defects performed in eight patients by means of controlled cross circulation. Surg. Gyn. Obst., 1955, 101: 446–466.
13. Lillehei, C. W., DeWall, R. A., Gott, V. L., and Varco, R. L. The direct vision correction of calcific aortic stenosis by means of pump-oxygenator and retrograde coronary sinus perfusion. Dis. Chest, 1956, 30: 123.
14. Lillehei, C. W., DeWall, R. A., Read, R. C., Warden, H. E., and Varco, R. L. Direct vision intracardiac surgery in man utilizing a simple, disposable artificial oxygenator. Dis. Chest, 1956, 29: 1–8.
15. Melrose, D. G., Dreyer, B., Bertoll, H. H., and Baker, J. B. E. Elective cardiac arrest. Lancet, Lond., 1955, 269: 21.
16. Pratt, F. H. The nutrition of the heart through the vessels of Thebesius and the coronary veins. Am. J. Physiol., 1898, 1: 86.
17. Read, R. C., Johnson, J. A., and Lillehei, C. W. Coronary flow and resistance in the dog during total body perfusion. Vol. VII. Surgical Forum 1956; American College of Surgeons. Chicago: American College of Surgeons, in press.
18. Roberts, J. T., Browne, R. S., and Roberts, G. Nourishment of the myocardium by way of the coronary veins. Fed. Proc. Balt., 1943, 2: 90.
19. Warden, H. E., Cohen, M., Read, R. C., and Lillehei, C. W. Controlled cross circulation for open intracardiac surgery. J. Thorac. Surg., 1954, 28: 331–343.
20. Warden, H. E., Read, R. C., DeWall, R. A., Aust, J. B., Cohen, M., Ziegler, N. R., Varco, R. L., and Lillehei, C. W. Direct vision intracardiac surgery by means of a reservoir of "arterialized venous" blood. J. Thorac. Surg., 1955, 30: 649–657.

FIBROUS METAPHYSEAL DEFECT OF BONE

CRAWFORD J. CAMPBELL, M.D., and JAMES HARKESS, M.D., Albany, New York

LOCALIZED BENIGN FIBROUS LESIONS of the metaphyses of long bones have been described as "nonosteogenic fibroma," "metaphyseal fibrous defect," "monostotic fibrous dysplasia," "giant cell tumor variant," "solitary xanthoma," "fibroxanthoma," "periosteal fibroma," "periosteal desmoid," "osteitis fibrosa," and "cyst-like area." Despite confusion of descriptive terms based on roentgenographic and pathologic characteristics, their benign nature has been recognized in all instances.

Sontag and Pyle, in 1941, studied the growth of the long bones in children from birth until the age of 18 years, using serial 6 month roentgenograms. They noted round, oval, or occasionally sacculated areas of decreased density measuring usually 1 to 3 centimeters in diameter, situated close to the zone of provisional calcification in the distal femoral epiphysis. The lesions were eccentrically located and much more frequent on the medial side of the metaphysis. Bilateral and multiple lesions were frequent. The incidence was 22 per cent in a group of 54 girls and 53 per cent in a group of 47 boys. These lesions were usually noted in children between the ages of 2 and 9 years, with an average age of 46 months. The average duration of the lesions as observed in the 6 month serial roentgenograms was 29 months. Small punched-out areas, measuring 1 to 2 millimeters in diameter, located in the juxtaepiphyseal area of the metaphyses were observed in roentgenograms taken 6 months prior to the appearance of the cyst-like lesions.

Jaffe and Lichtenstein, in 1942, described the pathologic picture of similar lesions which were larger in size and located at a distance farther from the epiphyseal plate than those described by Sontag and Pyle. The basic microscopic pattern consisted of whorled bundles of spindle-shaped connective tissue cells loosely interspersed with small, multinuclear giant cells. In some lesions foam cells were present. They believed that those lesions represented an unprovoked proliferation of autochthonous connective tissue and, hence, should be classified as a benign neoplasm which they designated as "nonosteogenic fibroma."

Hatcher (3), in 1945, noted the pathologic picture and course of this disorder. Defects in the metaphyses of young children were found to arise in the juxtaepiphyseal area and usually to heal rapidly by reparative ossification or, if they were located near the margin of the metaphysis, longitudinal growth and tubulation of the bone caused displacement to the outer surface of the bone and obliteration. If early repair did not occur, a metaphyseal defect usually became encapsulated by a thin sclerotic wall which gradually was obliterated by ossification from its walls. Occasionally there was no tendency to repair, and the lesions persisted in adult life. Hatcher noted the frequent occurrence of these localized fibrous lesions in association with the primary epiphyseal osteochondroses and believed that this might be a local manifestation of a more general aberration in endochondral growth. Other cases of multiple lesions have been reported by Ponseti, Adams, and Thompson.

The purpose of the present report is to define and attempt to clarify this lesion on the basis of its pathology, roentgenographic appearance, and clinical course. Attention is brought to aspects peculiar to this condition, such as the simultaneous occurrence of multiple lesions, its association with osteochondroses, and its course. This study is based on the records of 26 patients, of whom there

From the Department of Orthopaedic Surgery, Albany Medical College, Albany, New York.

FIG. 1. Roentgenograms of R. F., white male, aged 14 years, taken for a symptomatic Osgood-Schlatter's disease of the tibial tubercle, reveal an ovoid scalloped defect eccentrically located in the tibial metaphysis. It is surrounded by a thin shell of sclerosis, and there is no reaction in the regional bone.

were 20 males and 6 females, between the ages of 4 and 21 years. In 19 patients, the location was the distal femoral metaphysis, usually in the posteromedial portion. The site of involvement was the proximal tibia in 5 patients, the distal tibia in 4, and the proximal humerus in 1 patient. The lesion was noted in the roentgenograms which were made for complaints that were not attributable to the metaphyseal defect in all but 4.

Pathologic fractures in 3 patients healed without complication. One patient had mild pain over the affected site. Serum phosphorus, calcium, and phosphatase studies were normal in 4 patients so studied. Although the diagnosis of this entity was made on the basis of the roentgenograms, excision biopsy was done in 2 patients.

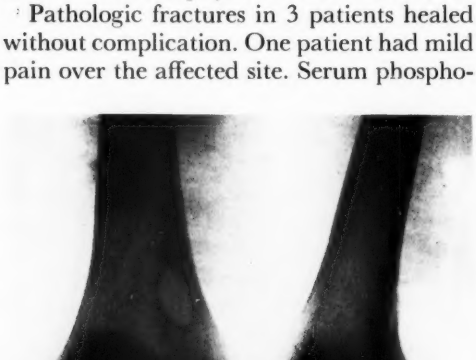


FIG. 2. M. C., white male, aged 8 years, sustained a contusion to the anterior knee. Roentgenograms reveal an ovoid eccentric lesion located within the cortex.

ROENTGENOGRAPHIC APPEARANCE

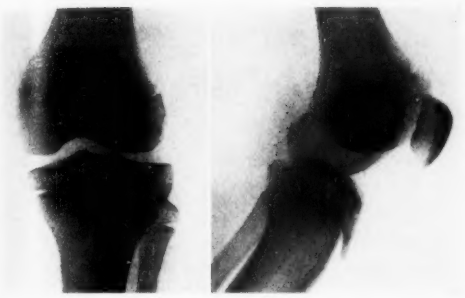
Characteristically, the lesion appears as an oval or elongated area of reduced density located eccentrically in the metaphysis of one of the more rapidly growing long bones (Fig. 1). The border is of scalloped contour and usually is slightly sclerotic. The defect is usually oriented in alignment with the long axis of the bone. It may lie entirely within the cancellous bone of the metaphysis or partially in the cortex (Fig. 2). Sometimes it may be situated in the outer margin of the cortex under the periosteum (Fig. 3a, b, and c). Its most frequent location is in the posteromedial aspect of the distal femoral metaphysis (Fig. 2). Serial roentgenograms may demonstrate obliteration of the defect by a gradual filling-in of bone.

PATHOLOGIC FINDINGS

The smooth-walled and often loculated cavity within the bone (Fig. 4a) contains a firm, white fibrous tissue in which there are spotty areas of yellowish or brownish coloration. This tissue, on microscopic examination, consists of mature connective tissue arranged in whorled bundles with interspersed small, and sometimes elongated, multinuclear giant cells (Fig. 4b and c). Areas of old hemorrhage with scattered collections of hemosiderin-loaded macrophages may be found. Lipoid-filled macrophages appear in those lesions which have been present for a long time. Centrally in the lesion there are usually no bone trabeculae. Marginally, however, newly formed reactive bone may be seen (Fig. 4b), and in some regions active osteoclasis of the old bone (Fig. 4b).

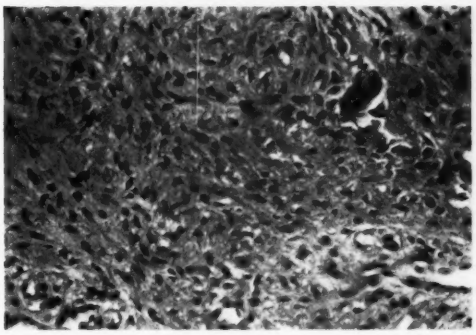
UNUSUAL FEATURES OF FIBROUS METAPHYSEAL DEFECT, MULTIPLE METAPHYSEAL DEFECTS

Sontag noted frequent bilateral involvement of the medial aspect of the distal fe-



a

b



c

FIG. 3. a, Roentgenograms of B. G., white female, aged 9 years, taken for a symptomatic Osgood-Schlatter's disease of the tibial tubercle show a small scalloped defect on the posteromedial side of the metaphysis of the lower femur just proximal to the epiphyseal line. b, Photomicrograph (×35) of the superior portion of the block excision biopsy of the defect in a, shows its subperiosteal location with destruction of the cortex. c, Photomicrograph (×200) of material from the center of the lesion shows a well differentiated fibrous tissue. Hemosiderin granules and a small multinucleated giant cell are present.

oral metaphysis. Hatcher (3) reported lesions in more than one bone in 5 of 45 patients. Separate adjacent foci were also noted in the same bone. Ponseti followed the course of 3 separate metaphyseal defects which originated from the same location in the juxtaepiphyseal area of the proximal metaphysis of the humerus. Adams reported a case with 7 large fibrous defects with symmetric involvement of the femoral and tibial metaphyses at the knee. There were multiple lesions in 8 of the 26 patients in our series. In 4, bilateral symmetric involvement of posteromedial aspect of femoral metaphysis was present (Fig. 5). Multiple foci aligned contiguously in same metaphysis were noted in 2 (Fig. 6). One patient had 4 separate lesions in the same metaphysis (Fig. 7).

ASSOCIATION WITH THE OSTEOCHONDROSES

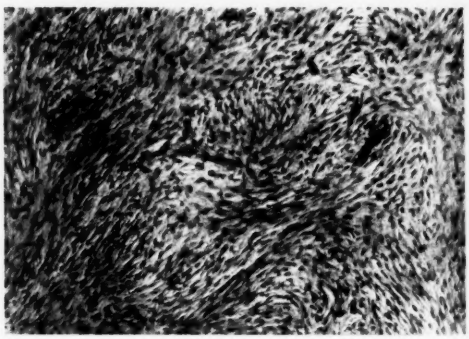
Hatcher (3) noted disturbance of the epiphyseal and bone cartilage in conjunction with metaphyseal defects in 14 of 45 patients. Eight of his patients had Osgood-Schlatter's disease, 4 had osteochondritis dissecans of the medial femoral condyle, and 2 had osteochondritis of the patella. Thompson reported 2 patients with multiple metaphyseal defects associated with osteochondritis of the vertebrae. In the present series, 8 of 26 patients had 1 or more lesions in close proximity to an osteochondritis. Five of these patients had Osgood-Schlatter's disease. Two had osteochondritis dissecans of the medial femoral condyle (Figs. 8 and 9) and 1 patient had osteochondritis dissecans of the patella. Two lesions in the distal tibia were associated with a calcaneal apophysitis (Fig. 10). Two in the distal femur and proximal tibia were associated with Legg-Perthes' disease.

COURSE OF FIBROUS METAPHYSEAL DEFECT

The natural course may be observed in serial roentgenograms of individual patients

a

b



c

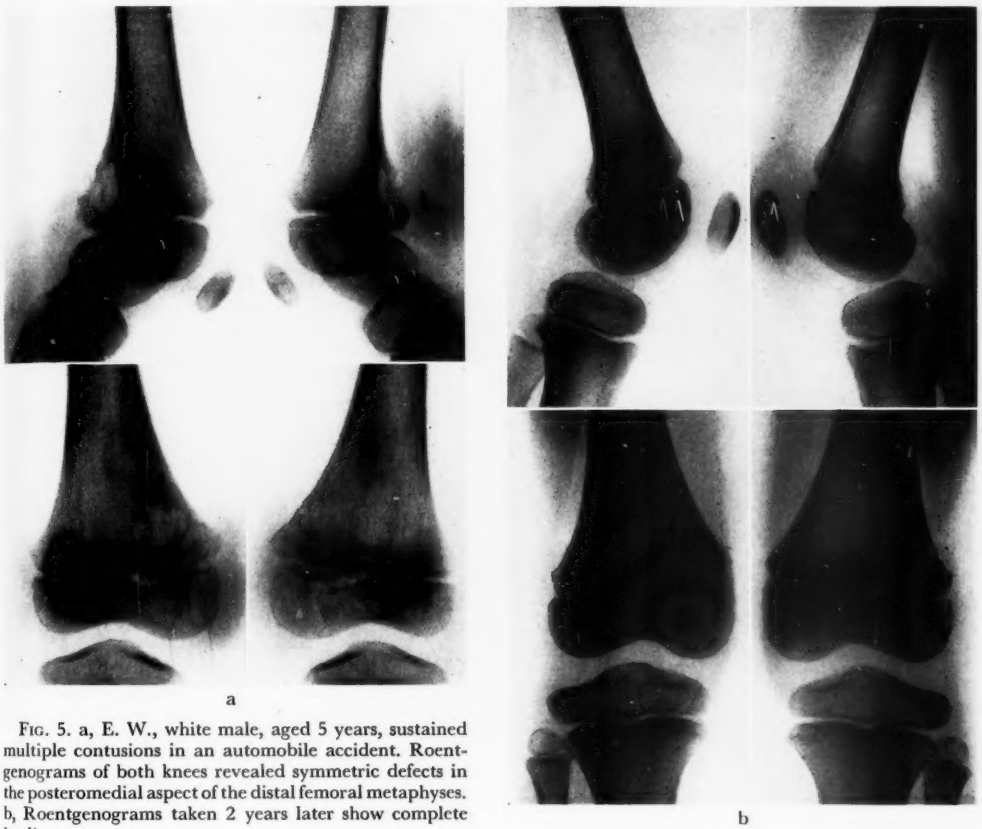
FIG. 4. a, White male, aged 19 years, sustained a direct blow over the medial femoral condyle. The roentgenogram shows a multiloculated cyst-like lesion located on the medial side of the metaphysis of the lower femur. Because of continued pain, the bone lesion was curetted. b, Photomicrograph (×57) of material removed from the margin in a, shows new bone formation which is normal in appearance. Some areas of osteoclasis of the old bone can also be noted along the margin of this lesion. c, Photomicrograph (×97) of material from the center of a, shows the whorled arrangement of closely packed, well differentiated connective tissue cells. A small multinucleated giant cell is present.

and in the roentgenographic and pathologic studies of a group of such lesions correlating the location of the lesion, the duration, and the pathologic picture. These defects arise in the juxtaepiphyseal area of the metaphyses of children and are first manifest as small punctate lesions measuring 1 to 2 millimeters in diameter.

Separate foci may appear simultaneously in the same metaphysis or in the metaphyses of separate long bones. Additional defects may form later from the same focus giving rise to contiguous lesions. Metaphyseal fibrous defects may enlarge or may heal spontaneously even early in their course (Fig 5). Sometimes a thin sclerotic wall encompasses the defect (Fig. 10). The process of tubulization of the growing bone may bring the focus adjacent to, or actually within, the cortex.

TREATMENT

Curettage or block excision was the treatment recommended by Jaffe and Lichtenstein, and more recently by Adams and Goldner, Devlin, Bowman, and Mitchell, and Kimmelstiel. Hatcher (3) and Ponseti believe that spontaneous regression and healing occur in most cases and that surgery is necessary in only the more extensive lesions in which a pathologic fracture is imminent. Curettage was done in 2 instances in this series following the healing of pathologic fractures (Figs. 10 and 11). These metaphyseal fibrous defects were discovered at the time of frac-



a b

FIG. 5. a, E. W., white male, aged 5 years, sustained multiple contusions in an automobile accident. Roentgenograms of both knees revealed symmetric defects in the posteromedial aspect of the distal femoral metaphyses. b, Roentgenograms taken 2 years later show complete healing.

ture and had not healed or regressed thereafter. Biopsy excision was done in 2 lesions (Figs 3 and 4). Many were noted to regress spontaneously within 1 to 3 years after their recognition (Fig. 5b). The nature of the lesion and its roentgenographic appearance in 21 cases was sufficiently clear so that neither biopsy nor surgical treatment was necessary.

DISCUSSION

Some of the confusion in the nomenclature of this entity arises from its superficial similarity to other bone lesions. Jaffe and Lichtenstein clarified the pathologic picture and differentiated it from giant cell tumor variant xanthoma, solitary bone cyst, and fibrous dysplasia and named it "nonosteogenic fibroma." Despite this fact, Schlumberger and more recently Adams and Goldner and Johnson suggest a relationship between ossifying fibroma, fibrous dysplasia, and this entity. They base their opinion on the presence of new bone formation located in fibrous tissue in all, and state that they are unable to differentiate the lesions histologically. We believe that the appearance of fine "embryonic" bone trabeculae dispersed irregularly through the lesion have a characteristic appearance in fibrous dysplasia. Bone formation occurring along the margin of a metaphyseal fibrous defect is not abnormal in microscopic appearance and is compatible with healing or with a reaction to chronic bone irritation. Other roentgenographic and pathologic features further distinguish these lesions.

FIG. 6.

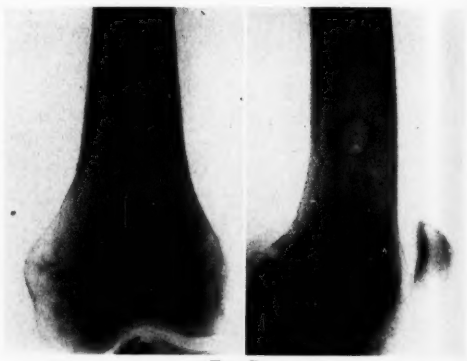


FIG. 7.

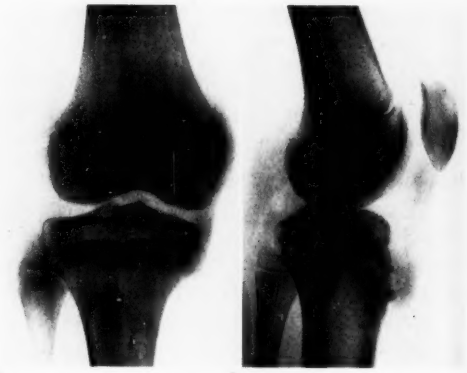
a

FIG. 8.

b

a

FIG. 9.



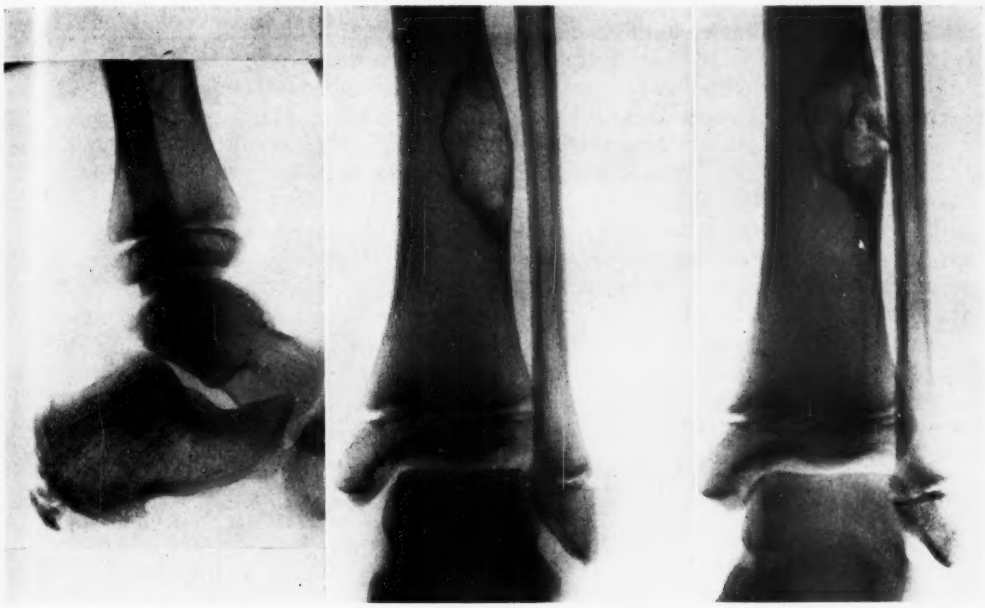
b

FIG. 6. D. R., white female, aged 8 years, injured her right knee in a fall. Roentgenograms show 2 contiguous defects aligned with the cortex.

FIG. 7. P. W., white male, aged 13 years, sustained a displaced fracture of the tibial tubercle. There are 4 defects in the distal femoral metaphysis.

FIG. 8. a, R. G., white male, aged 12 years, complained of pain over the right tibial tubercle and roentgenograms show an Osgood-Schlatter's disease on the right, and an osteochondritis dissecans of the medial femoral condyle. b, There were no complications in the left knee. Roentgenograms show an Osgood-Schlatter's disease of the tibial tubercle, an osteochondritis dissecans of the patella, and a fibrous defect in the proximal tibial metaphysis. Another fibrous defect was later noted in the distal femoral metaphysis.

FIG. 9. a, D. B., white male, aged 12 years, complained of pain over the tibial tubercle on the right. Roentgenograms show Osgood-Schlatter's disease of the tibial tubercle and a defect located in the posteromedial portion of the distal femoral metaphysis. b, There were no complaints about the left knee. The roentgenograms, however, reveal osteochondritis of the medial femoral condyle and Osgood-Schlatter's disease of the tibial tubercle



a b c

FIG. 10.

a b

FIG. 11.

FIG. 10. a, J. L., white male, aged 8 years, complained of severe pain over the calcaneal apophysis (the margin of a fibrous defect was noted in the roentgenograms). b, Roentgenogram of J. L. taken 3 years later for a sprain of the ankle shows an increased sclerosis along the margin of the fibrous defect. c, Eight months later the boy sustained a direct blow to the tibia. Roentgenogram reveals a pathologic fracture, and repeat films taken at 6 week intervals for 6 months following the healing of the fracture revealed no change in appearance of lesion. It was curetted and filled with bone chips. Rapid healing ensued.

FIG. 11. a, D. D., white male, aged 10 years, twisted his right ankle playing basketball. Roentgenograms reveal a pathologic fracture through a large defect located in the distal tibial metaphysis. b, The cyst-like lesion did not change following the healing of the fracture. It was curetted. Roentgenograms 6 months later show good healing.

The location of the lesion subperiosteally (Fig. 3) has influenced some authors to classify it as "periosteal desmoid" or "subperiosteal fibroma." We can find no basic pathologic difference between such defects located subperiosteally and those located deeper within the bone.

There is disagreement as to whether this entity represents a true tumor or a nontumorous connective tissue hyperplasia. The spontaneous regression or healing in most instances would suggest a nonneoplastic origin. Furthermore, the occurrence of multiple lesions and the frequent association with the osteochondroses suggest that a diffuse systemic disturbance is present in some cases.

SUMMARY

1. A study of 26 patients with 1 or more fibrous metaphyseal defects is reported in which spontaneous regression or healing occurred in all but a few instances.

2. Curettage or block excision resulted in healing in the 4 patients who were treated in this manner.

3. The appearance of multiple foci, as well as concurrent osteochondritic lesions, suggests a common systemic etiology.

4. We prefer the descriptive term "fibrous metaphyseal defect of bone" as suggested by Hatcher for this lesion since it identifies the location and the nonneoplastic fibrous tissue origin of this entity.

REFERENCES

1. Adams, J. P., and Goldner, J. L. Fibrous lesions of bone. South. M. J., 1953, 46: 529-536.
2. Devlin, J. A., Bowman, H. E., and Mitchell, C. L. Non-osteogenic fibroma of bone. J. Bone Surg., 1955, 37A: 472-486.
3. Hatcher, C. H. The pathogenesis of localized fibrous lesions in the metaphyses of long bones. Ann. Surg., 1945, 122: 1016-1030.
4. Idem. Personal communication, 1955.
5. Jaffe, H. E., and Lichtenstein, L. Non-osteogenic fibroma of bone. Am. J. Path., 1942, 18: 205-221.
6. Johnson, L. C. Discussion of reference 1.
7. Kimmelstiel, P., and Rapp, I. Cortical defect due to periosteal desmoids. Bull. Hosp. Joint Dis., N. Y., 1951, 12: 286-297.
8. Ponseti, I. V., and Friedman, B. Evolution of fibrous metaphyseal defects. J. Bone Surg., 1949, 31A: 582-585.
9. Schlumberger, K. G. Fibrous dysplasia of single bones. Mil. Surgeon, 1946, 99: 504.
10. Sontag, L. W., and Pyle, S. I. The appearance and nature of cyst-like areas in the distal metaphyses of children. Am. J. Roentg., 1941, 46: 185-188.
11. Thompson, P. Discussion of reference 1.

RETROCAVAL URETER

WILLARD E. GOODWIN, M.D., F.A.C.S., and
DONALD E. BURKE, M.D., Los Angeles, California, and
W. H. MULLER, M.D., F.A.C.S., Charlottesville, Virginia

ALTHOUGH UNCOMMON, retrocaval ureter is not as rare as it was formerly thought to be. Pick and Anson found only 26 cases previous to the one they reported in 1940. In a review in 1952, Abeshouse and Tankin recorded 58 cases. The most complete discussion of all aspects of the problem may be found in the doctoral thesis of Sesboué. Pratt and Newton reported the seventy-fifth case. A number of unreported cases have come to our attention.

The purpose of the present paper is to describe a case in which the diagnosis of retrocaval ureter was suspected after retrograde pyelography and definitely proved by the combination of catheterization of the vena cava and retrograde pyelography with stereograms before surgery. Treatment in this case consisted of freeing the ureter from its anomalous position after dividing the vena cava which was then reanastomosed. The logic of this procedure and arguments pro and con will be discussed.

So much has been written on the embryologic, historical, and other aspects of this odd congenital anomaly that it seems needless to repeat it here except in outline form:

1893	Hochstetter	first described this anomaly in humans.
1935	Kimbrough	first successfully divided and reanastomosed ureter (postoperative stricture required further ureteral dilation).
1940	Harrill	rendered first correct preoperative diagnosis; first to use the now accepted operation of division of renal pelvis, mobilization of ureter from behind the vena cava, and reanastomosis of the pelvis.
1950	Duff and Beard and Goodyear	used vena cavagram and pyelography to diagnose case.
1952	Leberman and associates	first demonstrated simultaneous catheterization of vena cava and ureter on a cadaver, but not on a patient.
1952	Cathro	first reported ligation and section of the vena cava in treatment of this anomaly; suggested reanastomosis of the vena cava.
1952	Sesboué	discussed sacrificing either kidney or the vena cava; concluded that sacrificing the vena cava was justified if disease or dysfunction existed in the opposite side. (Reanastomosis of the vena cava not mentioned in thesis.)
1952	Abeshouse and Tankin	recommended section and reanastomosis of the vena cava if possible.
1953	This Case	a combination of catheterization of the vena cava and retrograde pyelograms with stereoscopic films was employed to make definite preoperative diagnosis; patient successfully treated by division of the vena cava, mobilization of the ureter, and reanastomosis of the vena cava.
1954	Corbus	described a case which was treated by ligation and section of the vena cava in 1948, but was never previously reported.
1955	Pratt and Newton	reported the 74th and 75th cases; discussed Cathro's case favorably, "When the preservation of the involved kidney is of vital importance."

From the Section of Urology, Wadsworth General Hospital, Veterans' Administration Center, and the Department of Surgery (Divisions of Urology and General Surgery), the University of California Medical Center, Los Angeles, California.

FIG. 1.

FIG. 2.

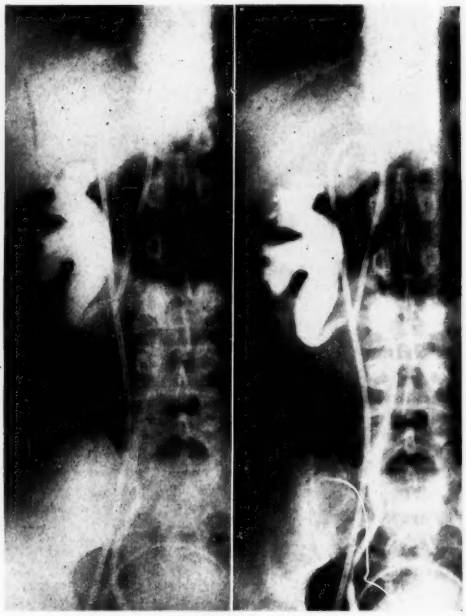


FIG. 3.

FIG. 1. Retrograde pyelogram, anterior-posterior view.
FIG. 2. Retrograde pyelogram, right-oblique exposure.

FIG. 3. Simultaneous catheterization of the vena cava and retrograde pyelogram, stereoscopic views.

DIAGNOSTIC CRITERIA

This anomaly should be considered in any case of unexplained right hydronephrosis. Anterior-posterior roentgenograms (Fig. 1) indicate that the ureter deviates to or across the midline and that its elongated upper portion forms a characteristic S curve. In right oblique roentgenograms (Fig. 2) the ureter hugs the spinal column. Stereoscopic views of simultaneous catheterization of the vena cava and ureter (Fig.3) demonstrate that the ureter is retrocaval at the point of intersection with the vena cava and that the lower midureteral segment lies anterior to the vena cava. The artist's drawing (Fig. 4) shows the anatomic arrangement demonstrated in Figure 3. Figure 5 presents a bas-relief of the findings in Figure 3, after the plastic photoroentgenographic method of Alexander.

TREATMENT

Treatment has consisted of the following: (1) nephrectomy for hydronephrosis; (2) section and reanastomosis of (a) the ureter or (b) the renal pelvis after removing the ureter from its position behind the vena cava; (3) ligation and division of the vena cava.

Primary nephrectomy has been performed in approximately 19 patients. As outlined in Table I, most patients have been treated by division and reanastomosis of the urinary tract. There have been many variants of this treatment, but these can be broken down into those cases which have been treated (a) by sectioning the ureter, freeing it from its position behind the cava, and reanastomosing it and (b) those treated as recommended by Harrill, who divided the renal pelvis, freed the ureter from behind the cava, and reanastomosed the pelvis where it was dilated. With 3 exceptions those cases treated by division and reanastomosis of the renal pelvis have done well. Those treated by division of the ureter and reanastomosis after freeing the ureter usually had good results. However, at least 7 patients treated in these

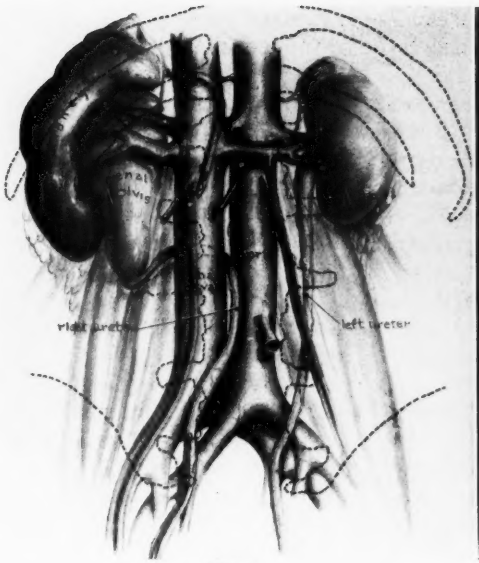


FIG. 4.

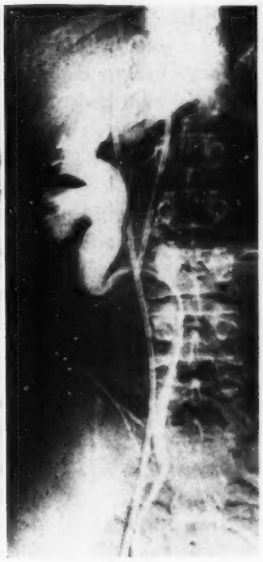


FIG. 5.

FIG. 4. Anatomic drawing illustrating Figure 3.
FIG. 5. Bas-relief photograph giving the third dimensional effect as seen in stereoscopic views of Figure 3.

ways have suffered severe complications (5 nephrectomies, 2 permanent nephrostomies).

The cases reported by Leberman and associates and Grossman and Fehr are examples of successful division and reanastomosis of the ureter, although the latter patient required some postoperative treatment. On the other hand, cases in which the operative reports sound exactly the same and yet the end results have led to nephrectomy occurred often enough to make one doubtful of the possibility of a 100 per cent satisfactory result with this form of treatment. For example, in the cases reported by Middleton and by Mullen and Engel, the operations as described sound technically perfect, yet the end results were impassable strictures and final nephrectomies.

As indicated in Table I, results were usually completely successful when the renal pelvis was sectioned and reanastomosed as first performed by Harrill. Creevy indicated that should he have another patient with this anomaly, he would perform Harrill's operation instead of sectioning the ureter and thus eliminate the need for postoperative ureteral dilations. Lyter and Meyer expressed a similar preference for Harrill's procedure, although at operation it was found that the renal pelvis of their patient was largely intrarenal and obscured by the vessels supplying the kidney. Excision of a cuff of pelvis was, therefore, thought to be technically impractical.

Although it is generally conceded that Harrill's operation is considered the procedure of choice, it may not always be applicable or completely successful. In personal communication, Burkland described his case in which division and reanastomosis of the renal pelvis was used with good early result, but the late complication of obstruction and infection led to eventual nephrectomy. Powell's similar patient with a solitary kidney has a permanent nephrostomy.

To our knowledge, division with ligation of the vena cava has been reported only twice in treatment of this condition. In 1952 Cathro

of Birmingham, England, reported a case in which he had divided the inferior vena cava. In his article (7) he states: "The ideal to be aimed at in all corrective surgery is the restoration of normal anatomy and function wherever possible. Although section of the inferior vena cava produced an excellent result in this case, an attempt at reanastomosis of the vein by a suture method should be worthwhile." He further adds: "Regarding the choice between an attack on the ureter or on the inferior vena cava, there can be no doubt that the caval operation is preferable when the other kidney is severely damaged or functionless, as in Lowsley's case."

Subsequent to Cathro's report, Corbus described a similar case. Although this operation was performed in April 1948, his case had never been reported previously. He describes the situation and his patient, who was a 26 year old farmer's wife, as follows: "I elected to section the vena cava in this instance, thereby not altering the urinary system, for three reasons: her age, occupation and religion. She has since, after a lifelong of suffering from urinary difficulty, rewarded my decision by having 3 additional children in the past 5 years without the slightest symptoms referable to her urinary tract." Abeshouse and Tankin also recommended division of the vena cava and, like Cathro, thought that reanastomosis would be a good idea if it were technically feasible. These authors provide whatever support there is in the literature for such a procedure.

CASE REPORT

D. M., a 26 year old white man, came under our observation with a 7 year history of pain in the right costovertebral angle and urinary symptoms of urgency, frequency, and pyuria. In 1947 he had seen a urologist who told him that he had cystitis and that the right renal pelvis contained 40 cubic centimeters of urine. He was given sulfonamide pills, and the right ureter was dilated intermittently for 3 months. The symptoms of irritation subsided, but after each ureteral dilation he had 3 to 5 days of pain in the right costovertebral angle with radiation to the lateral portion of his right thigh. He discontinued treatment and the symptoms improved except for occasional exacerbations.

In 1952 he saw another urologist because of severe recurrence of bladder irritation. Retrograde pyelograms were made, and he was told that he had a "malformation of the right kidney." He was given antibiotics and referred to the Wadsworth Veterans' Administration Hospital for an exploratory operation.

In the fall of 1953 he had a thorough urologic work-up including retrograde pyelograms. At that time his condition was diagnosed by another urologist as chronic cystitis, hydronephrosis, and possible renal tuberculosis. The initial intravenous pyelogram revealed right pyelectasis and chronic pyelonephritis on the left side. When the retrograde pyelograms were reviewed by one of us, however, the characteristic S curve of the right ureter was noted; and the diagnosis of retrocaval ureter was made. In order to substantiate the diagnosis further, it was decided to catheterize the vena cava (transfemorally) (20) and the right ureter simultaneously. Results are shown in Figure 3, and relationships between the catheters and the various anatomic structures are reproduced in Figure 4. When properly viewed, stereoscopic roentgenograms made with catheters in place add the third dimension and prove the diagnosis.

Since the diagnosis was positive, attention was then turned to treatment. A review of previous results, which had followed division and reanastomosis of the urinary tract in treatment of retrocaval ureters, led us to consider division of the vena cava as an alternative. At first division of this major vein as a treatment of a primarily urologic lesion seemed too formidable a procedure until we weighed the results of more conservative surgical management and the bilateral upper tract disease in this patient. Since retrograde pyelograms in this case showed evidence of pyelonephritis on the *left side* in addition to the right sided pathology caused by the retro-

TABLE I.—URETEROPLASTIC AND PYELOPLASTIC TREATMENT FOR RETROCAVAL URETER

Report year	*Author*	*Postoperative complications*	*Postoperative treatment*
		SECTION AND REANASTOMOSIS OF THE URETER	
1935	Kimbrough	UPJ obstruction	Periodic dilation
1936	Uebelhor	None	None
1938	May	None	None
1946	Greene and Kearns*	Leakage	Planned periodic dilation; nephrectomy 2 yrs. later (personal communication)
1946	Lowsley*	Stricture of terminal ureter and nephrostomy	Two reoperations; permanent catheter drainage; solitary kidney
1946	Nourse and Moody*	Leakage, infection, calcium concretions	Secondary nephrectomy (5 mos.)
1946	Goyanna *et al.*	None	None
1948	Creevy	Slight stricture	Periodic dilation for 3 mos.
1948	McElhinney and Dorsey	Narrowed ureter	Periodic dilation
1949	Shearer	Stricture	Periodic dilation; late results perfect
1949	Lyter and Meyer	Twisted ureter adherent to vena cava	Secondary operation; biweekly dilations
1950	Olsen and Austen	None	None
1951	Dougherty	Delay in function of right kidney	Dilation of ureter 9 times
1951	Middleton	Stricture; renal fibrosis	Secondary nephrectomy
1951	Schmidt *et al.*	Pyelitis	Sulfonamide therapy (2 mos.)
1952	Dufour and Sesboué	Infection	Penicillin and streptomycin (10 days)
1952	Leberman *et al.*	None	None
1953	Grossman and Fehr	Moderate hydronephrosis persisted	Periodic dilations
1955	Pratt and Newton	Thrombophlebitis	None
1955	Christeson	None	None
		SECTION AND REANASTOMOSIS OF THE RENAL PELVIS (HARRILL'S PROCEDURE)	
1940	Harrill	None	None
1949	Anderson and Hynes	None	None
1950	Jacobson	None	None
1951	Heslin and Mamonas	Infection	Gas gangrene antitoxin
1951	Parks and Chase	None	None
1952	Mullen and Engel*	Ureteral calculus	Secondary nephrectomy
1955	Burkland*	Persistent hydronephrosis and infection	Nephrectomy (personal communication)
1956	Powell*	Failure of anastomosis	Permanent nephrostomy; solitary kidney (personal communication)

*Unsatisfactory results

caval ureter, we were reluctant to consider any treatment which would admit possibility of failure. The problem was reviewed with general and vascular surgeons who often divide and reanastomose major vessels. After considerable discussion and consultation, it was decided that it would be reasonable to attempt division and reanastomosis of the vena cava in this case. This procedure was carried out November 9, 1953. The operative notes are as follows:

Exploration and mobilization of retrocaval ureter: division and reanastomosis of the vena cava: nephropexy, right. The patient was placed in the right flank position, and a conventional kidney incision was made under the twelfth rib. It was extended anteriorly on the abdominal wall, downward toward McBurney's point (Fig. 6, inset). Dissection was carried through all layers of the abdominal muscles, and the retroperitoneal space was entered. The peritoneum was pushed forward and dissection continued downward along the psoas muscle until the right ureter was identified. Dissection was extended medially, and the vena cava was identified. The anatomy was exactly as had been anticipated from the roentgenograms. From below, the ureter passed over the iliac vessels and then coursed medially and anteriorly to the vena cava. When the ureter reached the middle portion of the vena cava, at approximately the third lumbar level, it coursed posteriorly between the vena cava and the aorta, curved behind the cava and joined laterally to a hydronephrotic renal pelvis. The ureteral dilatation ended abruptly where the ureter curved to go under the vena cava. Blunt dissection freed the ureter and clearly delineated the anatomy of the area (Fig. 6).

At this time Dr. Goodwin consulted with Dr. Muller to determine whether the vena cava or the renal pelvis should be divided. Various arguments on both sides were expressed. It was pointed out that division of the renal pelvis was technically simple but might be fraught with the difficulty that peristalsis and

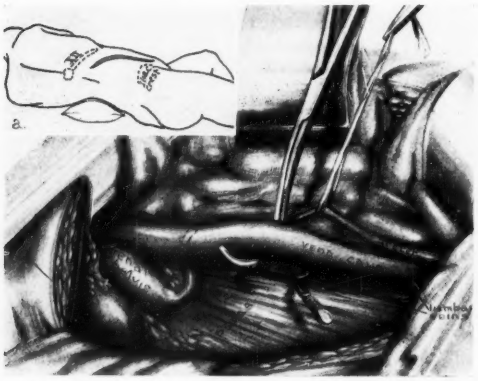


FIG. 6. The surgical procedure; exposure of the field of operation.

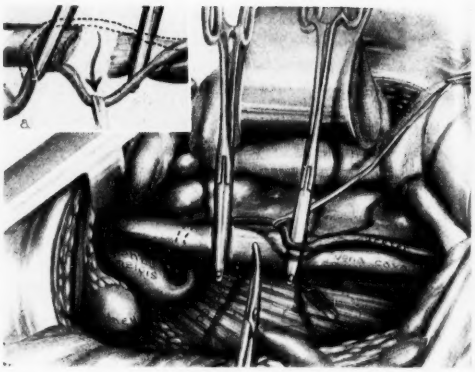


FIG. 7. The surgical procedure: occlusion and division of the vena cava; mobilization of the intact ureter.

blood supply would be interrupted. Dr. Muller thought that division of the vena cava was relatively easy and possibly safer than division of the ureter in this case of bilateral urinary tract disease. It was then agreed that caval division was the procedure of choice in this case.[1]

After freeing the cava from its fascia, coarctation clamps were placed 1½ to 2 inches apart where the ureter coursed behind it. A small bulldog clamp was also placed on one of the lumbar veins. Care was exercised in placing these clamps so that the ureter could easily be freed from behind (Fig. 7). When the vena cava was divided with scissors, the ureter was pulled into its normal lateral position (Fig. 7 inset). Following this procedure, the cava was reanastomosed with triangulation stitches; a continuous suture of No. 0000 black silk was placed between the 3 primary sutures in such a way that there was tight closure (Fig. 8). It was at first difficult to achieve approximation. However, a rapid acting muscle relaxing drug given by the anesthetist, plus flexing the center of the operating table, afforded adequate relaxation and made the anastomosis possible. When the occluding clamps were removed, there was little or no bleeding. Interestingly, the patient's blood pressure rose precipitantly as blood from the lower extremities rushed upward. The blood pressure slowly dropped to normal levels thereafter, and the patient seemed to suffer no ill effects from the procedure. The vena cava was occluded approximately 50 minutes.

[1]Dr. Muller performed the division and reanastomosis of the vena cava.

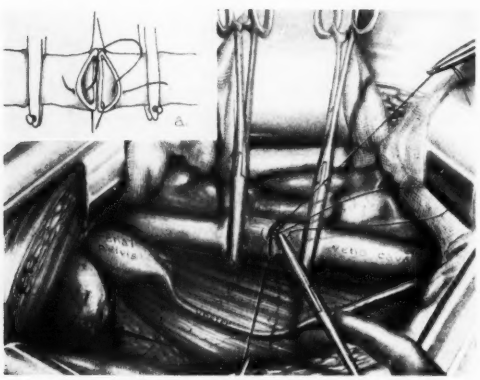


FIG. 8. The surgical procedure: anastomosis of the vena cava; nephropexy; lateralization of the elongated ureter.

Attention was then turned to freeing the ureter still further by blunt dissection. It was necessary *to divide the artery leading to the middle third of the ureter* so that the ureter could be pulled laterally and placed on the psoas muscle in a lateral position. In order to secure it in this position, the peritoneum was tacked to the psoas muscle with several mattress sutures placed medial to the ureter. Nephropexy was accomplished by a single mattress suture of catgut placed in the lower pole of the kidney and brought out between the eleventh and twelfth ribs. Gerota's fascia was drawn down below the lower pole of the kidney for added support. This seemed to permit the ureter to fall in a long lateral curve.

Because of the danger of draining urine into the wound, and the fact that the ureteropelvic junction appeared to be free of intrinsic obstruction, it was decided not to open the urinary tract or to perform further surgery on the ureteropelvic junction. The wound was closed in layers with interrupted chromic catgut sutures. No drains were used. The skin was closed with interrupted black silk. The patient received 1 transfusion and withstood the procedure very well.

The postoperative course was entirely benign. Heparin was given for the first 36 hour

He was out of bed on the first postoperative day and left the hospital on the sixteenth postoperative day. When he was seen a year later, intravenous pyelograms revealed nearly normal upper urinary tracts, considering the diseased left side. The patient had no complaints, no further urinary difficulties and no back pains. Figure 9 shows a normal postoperative intravenous pyelogram 1½ years after the original operation. He continues well 3 years after surgery.

FIG. 9. Postoperative intravenous pyelogram, 1½ years after treatment.

DISCUSSION

This seemed an unusual case and was presented as such in an exhibit at the Western Urological Section and the American Urological Association meetings in 1954. There was considerable interest in this case, but many colleagues questioned the wisdom of this form of treatment. The major surgical procedure of dividing and reanastomosing the vena cava was considered by some to be too radical an approach for the correction of a primarily urologic lesion. Although we had considered the treatment justified in this case and the results excellent, we were struck by this air of criticism and presented the following questions with the exhibit:

Would you divide the vena cava in the treatment of retrocaval ureter, *given a patient with disease in contralateral kidney*?

I would_____

I would not_____

Have you treated a patient with retrocaval ureter?

Yes_____

No_____

Only 37 urologists filled out the questionnaires. The answers, nonetheless, were interesting: Twenty-two answered that they "would not," and 13 indicated that they "would," with the aid of a vascular surgeon. Two gave indefinite answers. There were a few qualifying remarks, perhaps some of them in jest. One urologist wrote, "I would not . . . (Keep the general surgeons out)." Another wrote, "I would with the aid of a vascular surgeon."

One colleague who had never seen a case of retrocaval ureter but who has a vast, reported experience with successful anastomosis of accidentally divided ureters due to pelvic surgery considered it almost malpractice to divide the vena cava rather than the urinary tract. Division of the postcaval portion of an anomalous ureter, however, may not be the same as other types of ureteral division because of the necessary interruption of ureteral blood supply which follows mobilization and relocation of the ureter.

In answer to the question, "Have you treated a patient with retrocaval ureter," the results were "No"—21, "Yes"—13. One of the latter had seen 3 cases and another had seen 2. A number of these cases were not reported.

Because we were struck with the observation that most of the 13 surgeons who answered that they had treated patients with retrocaval ureters were also the ones who answered that they would consider treating this condition by division of the vena cava and reanastomosis with the aid of a vascular surgeon, it occurred to us to seek the reaction of the men who had written about this interesting subject. Accordingly, the report of this case and the illustrations, much as presented here, were mimeographed and sent to 30 men who have reported cases of retrocaval ureter. They were asked specifically the two following questions:

1. Do you think the method of surgical treatment in this case was justified?

2. Would you favorably consider this form of treatment if you had a case of retrocaval ureter with disease in the opposite kidney?

Twenty-six replies were received.

Of the 26 replies, 20 answered "Yes" to question 1, and 6 answered "No." Question 2 was answered affirmatively 21 times and negatively 5 times. Some of the men who had originally reacted unfavorably to this procedure had altered their opinions and now favored it under the given circumstances as they became more familiar with the details of the case. Those who favored the procedure were unanimous in indicating that they would want to have a vascular surgeon handle the surgery on the vena cava. Several men, although agreeing with the idea, said that they doubted that it could be done in their communities because there were not yet vascular surgeons of sufficient ability to perform this type of surgery.

All of the answers pro and con were instructive indeed. It is a temptation to quote liberally from this interesting correspondence, as some of the writers expressed themselves very forcibly on both sides of the question. However, the summary of the figures speak for themselves, and it seems best to leave the actual opinions anonymous.

The tenor of these communications reinforces our original belief that division and reanastomosis of the vena cava constitute reasonable and good treatment in skilled hands, providing it is of supreme importance to preserve the kidney on the side of the obstruction without any question of later damage. However, the well trained urologist working alone without the advantage of consultation and help from a vascular surgeon should employ Harrill's operation of division and reanastomosis of the renal pelvis, or, if necessary, Cathro's procedure of ligation and division of the vena cava without re-establishing its continuity.

SUMMARY

The history of diagnosis and treatment of the congenital anomaly, retrocaval ureter, is briefly traced. A case is presented in which the diagnosis was firmly established before operation by catheterization of the vena cava in combination with retrograde pyelograms made by stereoscopic x-ray technique. This case was treated by surgical division of the vena cava, mobilization, and relocation of the ureter, and reanastomosis of the cava by a skilled vascular surgeon. The end result was excellent. The pros and cons of division of the vena cava in treatment of retrocaval ureter are discussed.

CONCLUSION

Retrocaval ureter should be considered in any case of unexplained right hydronephrosis. The diagnosis can be established definitely by adequate preoperative roentgenographic techniques. From the literature it would seem that the best treatment in the hands of a skilled urologist, working alone, is division and reanastomosis of the dilated renal pelvis. The results of division of the urinary tract with reanastomosis have not been uniformly good. In selected cases, division of the vena cava may be the treatment of choice. This is particularly true when there is absence of the left kidney or disease in the left kidney. We believe this procedure has a useful place when the vascular surgery can be performed by a competent vascular surgeon. Adequate and correct preoperative diagnosis is important.

REFERENCES

1. Abeshouse, B. S., and Tankin, L. H. Retrocaval ureter; report of a case and review of the literature. Am. J. Surg., 1952, 84: 383.
2. Alexander, B. Plastic roentgenography. Arch. Roentgen Ray & Allied Phenomena, 1908, 12: 216.
3. Anderson, J. C., and Hynes, W. Retrocaval ureter; case diagnosed preoperatively and treated successfully by plastic operation. Brit. J. Urol., 1949, 21: 209.
4. Beard, D. E., and Goodyear, W. E. Retrocaval ureter; case report. Urol. Cut. Rev., 1950, 54: 80.
5. Bowers, R. F., and Leb, S. M. Late results of inferior vena cava ligation. Surgery, 1955, 37: 622.
6. Burkland, C. E. Personal communication.
7. Cathro, A. J. A. Section of inferior vena cava for retrocaval ureter. J. Urol., Balt., 1952, 67: 404.
8. Corbus, B. C. Urologist's correspondence club letter, June 7, 1954.
9. Creevy, C. D. Recognition and surgical correction of retrocaval ureter. J. Urol., Balt., 1948, 60: 26
10. Dougherty, J. A. Circumcaval ureter. California M., 1951, 75: 48.

11. Duff, P. A. Retrocaval ureter: case report. J. Urol., Balt., 1950, 63: 497.
12. Dufour, A., and Sesboué, P. Uretère rétro-cave diagnostique avant l' opération et guéri par uretèroplastie. J. urol. méd., Par., 1952, 58: 390.
13. Goyanna, R., Cook, E. N., and Counseller, V. S. Circumcaval ureter. Proc. Mayo Clin., 1946, 21: 356.
14. Greene, L. E., and Kearns, W. M. Circumcaval ureter. J. Urol., Balt., 1946, 55: 52.
15. Grossman, S. L., and Fehr, J. U. Retrocaval ureter. Am. J. Surg., 1953, 85: 679.
16. Harrill, H. C. Retrocaval ureter; report of a case with operative correction of the defect. J. Urol., Balt., 1940, 44: 450.
17. Heslin, J. E., and Mamonas, C. Retrocaval ureter. J. Urol., Balt., 1951, 65: 212.
18. Hochstetter, F. Beitrage zur entwickelungsgeschicktedes venen systems der amnioten. Anat. Anz., 1888, 3: 938.
19. Jacobson, C. E. Retrocaval ureter; case report. Connecticut M. J., 1950, 14: 709.
20. Kaufman, J. J., Burke, D. E., and Goodwin, W. E. Abdominal venography in urological diagnosis. J. Urol., Balt., 1956, 75: 160.
21. Kimbrough, J. C. Surgical treatment of hydronephrosis. J. Urol., Balt., 1935, 33: 97.
22. Leberman, P. R., Zinsser, H. H., and Franklin, M. Retrocaval ureter; case report and a new diagnostic approach. J. Urol., Balt., 1952, 68: 679.
23. Loughlin, V. C. Retrocaval (circumcaval) ureter associated with solitary kidney. J. Urol., Balt., 1954, 71: 195.
24. Lowsley, O. S. Postcaval ureter with description of a new operation for its correction. Surg. Gyn. Obst., 1946, 82: 549.
25. Lyter, C. S., and Meyer, W. C. Retrocaval ureter; a case report. Urol. Cut. Rev., 1949, 53: 718.
26. May, F. Verstopfungsniere bei dorsalem Ureterverlauf. Zschr. Urol., 1938, 32: 316.
27. McElhinney, P. P. B., and Dorsey, J. W. Retrocaval ureter. J. Urol., Balt., 1948, 59: 497.
28. Middleton, A. W. Post-caval ureter; a case preoperatively diagnosed with confirmation at surgery. Rocky Mountain M. J., 1951, 48: 186.
29. Mullen, W. H., and Engel, W. J. Circumcaval ureter. Radiology, 1952, 59: 528.
30. Nourse, M. H., and Moody, H. C. Postcaval ureter; report of a surgical case. J. Urol., Balt., 1946, 56: 525.
31. Olsen, R. O., and Austen, G. Postcaval ureter, report and discussion of a case with successful surgical repair. N. England J. M., 1950, 242: 963.
32. Parks, R. E., and Chase, W. E. Retrocaval ureter; report of 2 cases diagnosed preoperatively in childhood. Am. J. Dis. Child., 1951, 82: 442.
33. Pick, J. W., and Anson, B. J. Retrocaval ureter; report of a case with a discussion of its clinical significance. J. Urol., Balt., 1940, 43: 672.
34. Powell, T. Personal communication.
35. Pratt, A. M., and Newton, R. G. Retrocaval ureter; report of two cases and review of literature. Tr. Southeastern Sect. Am. Urol. Ass., 1955, 18.
36. Schmidt, C. R., Huebert, D. W., and Beazell, J. M. Retrocaval ureter. Arch. Surg., 1951, 62: 299.
37. Sesboué, P. L'uretère rétro-cave. Paris: Imprimerie R. Foulon, 1952.
38. Shearer, T. P. Retrocaval ureter. J. Urol., Balt., 1949, 62: 152.
39. Uebelhor, R. Hydronephrose bei Abnormität der unteren Höhlevene. Zschr. Urol., 1936, 30: 769.

SURGICAL APPROACH TO THE LATERAL (PERONEAL) SIDE OF THE KNEE JOINT

EMANUEL B. KAPLAN, M.D., F.A.C.S., New York, New York

THE PREREQUISITES of an adequate surgical approach to any joint and, in this instance, to the knee joint, are: (1) precise knowledge of the anatomy of the region; (2) expedient choice of the most direct exposure of the structures requiring surgical treatment; (3) rapid orientation, if extension of the original incision is required; and (4) consideration of immediate and final postoperative function with minimal sacrifice of structures consistent with the requirements of the operation.

Precise knowledge of the anatomy of a region must include more than simple description of structures. Omissions in the presentation of surgical approaches are found occasionally because they are given in connection with surgical techniques for specific operations emphasizing a particularly important point. The relationships of structures are shown either in a standard position of a limb or joint, or in one position. Fundamental principles for a universal approach are seldom considered.

However important and necessary are the descriptions of improved specific techniques, a broader insight into the anatomy of regions is essential for immediate practical purposes and for future progress. The purpose is not only to identify unmistakably the constituents of a region but also to understand them as functional and morphologic units.

The relative location of structures shifts when the position of a joint changes. Mutual relationships alter in the transition from flexion to extension or from lateral to medial rotation in certain joints; also, angles are modified, distances between structures increase or diminish, and sometimes unrelated structures in one position come into actual alignment in another. Thus, a broad understanding of the anatomy of a region must include comprehension of the embryology and comparative anatomy, as well as alterations in the spacial interrelation of structures with changes of position.

The present study is a result of several related investigations concerning the knee joint. A limited study of the embryology of the knee joint brought some information on the significance and development of the menisci. Comparative anatomic studies were made on a relatively large number of representative animals. These studies were supplemented with observations on live animals whenever possible for understanding of function. Human knees of various age groups were dissected in the regular manner and transsected in different planes. Functional and anatomic observations of the living human knee were made in the course of surgical procedures by the author for the treatment of various knee injuries and diseases in adults and children.

The lateral aspect of the knee joint in this study covers the space between the lateral border of the patella extending posteriorly to the midline of the popliteal space. Proximally, this space is limited by the posterior extension of the horizontal line separating the shaft of the femur from the lateral condyle. Distally, the area is limited by a horizontal line running through the neck of the fibula.

The reason for choosing this area lies in its self-contained anatomic and functional importance. It has significant capsulofascial structures including the iliotibial band, the tendon of the biceps femoris muscle, and the

From the Department of Anatomy, College of Physicians and Surgeons, Columbia University and Hospital for Joint Diseases, New York.

lateral collateral ligament. The morphologic and functional connections of these structures are more complicated than it is realized, especially when the function of the popliteus tendon and muscle is considered. The lateral semilunar cartilage, the posterior cruciate and meniscofemoral ligaments, and the lateral head of the gastrocnemius play a very important role in the local harmony of function.

The common peroneal nerve (the external popliteal), which runs behind the posterior border of the biceps femoris, crosses the plantaris muscle, the lateral head of the gastrocnemius and the popliteus muscles; it also crosses the inferior lateral genicular vessels and reaches the neck of the fibula where it breaks up into its three branches. The nerve crosses this region obliquely from the superoposterior angle downward and forward toward the inferior anterolateral angle of the lateral aspect of the knee. The posterior border of the lateral aspect is limited by the tibial nerve and by the popliteal vein and artery.

The ligamentous structures of this side of the knee joint, the tendons, and lateral meniscus were extensively studied by surgeons and anatomists. Generally, however, the results of the original investigations are not widely known by the majority of surgeons. It is also becoming apparent that reinvestigation of some of the comparative anatomic material would be very helpful in the light of modern surgical experience.

ANATOMY OF THE LATERAL SIDE OF THE KNEE JOINT

Surface anatomic reference points are useful to the surgeons. There are several points over the lateral aspect of the knee joint, as for instance, the anterior tibial tubercle, the lateral tibial tubercle (tubercle of Gerdy), and the tip of the head of the fibula. A line uniting these three points runs in a posterior and proximal direction. The anterior tibial tubercle is the most distal and anterior; the lateral tibial tubercle is more proximal and more posterior; the tip of the fibular

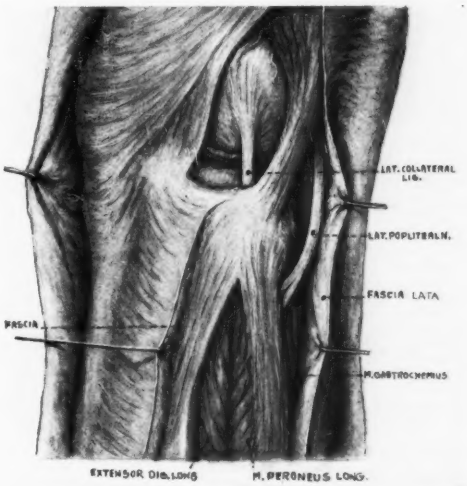


FIG. 1. Lateral aspect of left knee. Showing continuity of biceps muscle insertion over fascia of leg muscles. Window in fascia lata between iliotibial band and biceps tendon.

head is the most proximal and most posterior of the three (Fig. 12). The relationship of these three tubercles remains unchanged irrespective of the position of the knee. When the knee is in extension, the apex of the patella, palpable through the ligamentum patellae and united by a line with the tip of the head of the fibula, indicates the direction of the interarticular line of the knee joint about 1 centimeter above the meniscus. This line can be used cautiously for penetration into the knee joint, if it is remembered that an indiscriminate use would divide transversely the lower fibers of the iliotibial band, somewhat obliquely the tendon of the popliteus muscle, and straight across the lateral collateral ligament and biceps tendon.

The lateral surface of the condyle presents an important reference point, namely the lateral supracondylar tubercle. This is similar to the medial supracondylar tubercle. The medial supracondylar tubercle is located higher on the femur than the lateral tubercle. The lateral tubercle is in line with the base of the patella when the knee is extended. Posteriorly, the constant skin crease of the popliteal space, which is exaggerated on

FIG. 2. Deeper dissection. Complicated arrangement of the tendon of insertion of the biceps femoris to the lateral collateral ligament. Superior lateral genicular artery seen emerging from the front of the biceps muscle.

flexion of the knee joint, is located about 2 centimeters proximal to the joint line.

The subcutaneous fat over the lateral aspect of the knee is usually much thinner than the subcutaneous fat of the medial aspect. However, it becomes much thicker, as the popliteal space is approached. The vascular supply of the surface is derived from the superior lateral genicular vessels at the level of the base of the patella and from the inferior lateral genicular arteries at the interarticular line. Except for extensive varicosities encountered occasionally, no special vascular problems are met with. The nerve branches for the subcutaneous strata derive from the lateral and posterior femoral cutaneous nerves. The visible nerve branches should not be divided on operation because anesthesia of the skin over the lateral aspect of the knee is just as disturbing as the division of the genicular superficial branch of the saphenous nerve on the medial side.

The skin incisions over the lateral aspect are placed in accordance with principles of plastic surgery, as much as practicable. Curved incisions of various shapes were and are being used. In the author's experience, oblique straight incisions appeared to heal better than transverse incisions.

Incision with retraction of the skin exposes the fascial structures which assume a special significance because the fascia is intimately connected with the ligamentous apparatus of the knee. The first fascial layer deep to the superficial is represented by the fascia lata which continues to envelop the knee from the thigh. The fascia adheres intimately to the anterior tubercle of the tibia, to the lateral tibial tubercle of Gerdy, and to the head of the fibula. Over the head of the fibula the fascia is connected with the tendon of the biceps which itself surrounds the fibular portion of the lateral collateral ligament. The tendon of the biceps expands into the fascia lata and appears to continue its insertion into the fascia covering the muscles of the leg. In a number of mammals, the biceps muscle does not insert into the head of the fibula at all and simply expands into a wide fascia insertion covering the muscles of the leg below the knee joint (Fig. 6). The fascia lata also adheres intimately to the lateral supracondylar tubercle of the femur and, thus, blends into the lateral intermuscular septum. It covers the lateral femoral condyle and descends to the lateral tubercle of the tibia where it is inserted in conjunction with the iliotibial band (Fig. 1). The iliotibial band is a thickening of the fascia lata running from the base of the greater trochanter to the lateral tubercle of the tibia. As an integral part of the fascia lata, the iliotibial band is attached firmly to the lateral supracondylar tubercle of the femur. Running in a distal direction, it spans the lateral side of the knee joint without adhering to the capsule and ends at the lateral tubercle of the tibia. The anterior part of the iliotibial band curves forward forming a group of arciform fibers blending with the fascia over the patella. The posterior fibers thin out considerably and blend with the fascia covering the biceps tendon. This area of thin fascia between the anterior border of the biceps tendon and the posterior border of the thick iliotibial band represents an area where the capsule of the knee joint is most accessible (Fig. 2).

The anterior expansion of the fibers of the iliotibial band blend into the fascia lata which covers the patellar region superficial to the quadriceps apparatus. The four parts

of the quadriceps apparatus converge toward the patella. They are inserted into the base and into a part of the lateral and medial borders of the patella. The two vasti send some thickened longitudinal fibers parallel to the patellar tendon and running on each side of the patella toward the tibia forming the longitudinal retinaculae. The two vasti muscles also send oblique cross fibers over the surface of the combined strong patellar tendon in intimate contact with the anterior surface of the patella. The fascia lata covers the patellar region but does not adhere to the quadriceps apparatus. A space is formed known as the prepatellar bursa. In the lateral approach to the knee joint it is useful to remember that the fascia adheres firmly to the lateral border of the patella. By virtue of this adhesion, the prepatellar bursa never extends beyond the lateral border of the patella, in contrast to the medial side where the prepatellar bursa extends from 2 to 3 centimeters medially beyond the medial border of the patella.

The iliotibial band plays an important role in the stability of the knee joint. In an investigation on the function and morphogenesis of this band, the author found that contractions of the tensor fasciae latae muscle transmit minimal power to the knee joint. The iliotibial band acts mostly as a stabilizer of the knee joint. It is therefore essential to avoid division of the band, especially, if for some reason the lateral collateral ligament also has to be divided. The preservation of the iliotibial band in cases of division of the lateral collateral ligament will help to preserve the stability of the knee joint. In 3 cases of complete resection of the fibular head with section of the lateral collateral ligament and tendon of the biceps muscle, but with preservation of the iliotibial band, there was no instability of the knee joint.

However, the problem of knee stability is more complicated than usually assumed. The role of the stabilizing effect of the popliteus tendon and muscle was not sufficiently delineated. The important role of this muscle was described in 1858 by Furst but for some

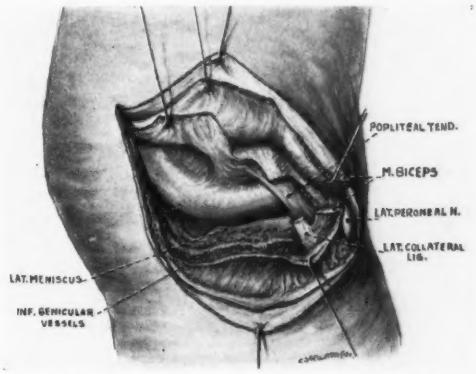


FIG. 3. Oblique transverse lateral incision. Left knee joint. The lateral collateral ligament is partially resected to show the relation of the popliteus tendon to lateral collateral ligament, biceps muscle insertion, and fascia lata.

reason almost completely escaped the attention of the surgeons. The popliteus muscle still is considered by some to be a flexor and medial rotator of the leg. The popliteus is actually a pure medial rotator without any significant flexion component. In rotatory movement, which is not great in the human knee joint, the action of the popliteus is probably transferred to stabilization of the knee in flexion. The posterior cruciate ligament, especially in conjunction with the lateral meniscofemoral ligaments, also plays a role. Thus, in surgery of this part of the knee, stability may be preserved if 2 of the important structures are preserved: either the iliotibial band and popliteal tendon, or the lateral ligament and popliteal tendon, or the iliotibial band and the lateral ligament.

Underneath the fascia lata and its iliotibial band is the capsule of the joint with reinforcements on each side. The reinforcing ligaments of the capsule vary in thickness. The meniscopatellar and femoropatellar are described. Their name indicates their location. They are not constantly found and represent ligaments connecting the sesamoid bones of the gastrocnemii with the patella in certain species. They are apparently without special significance in man, and their surgical severance does not produce any functional consequences.

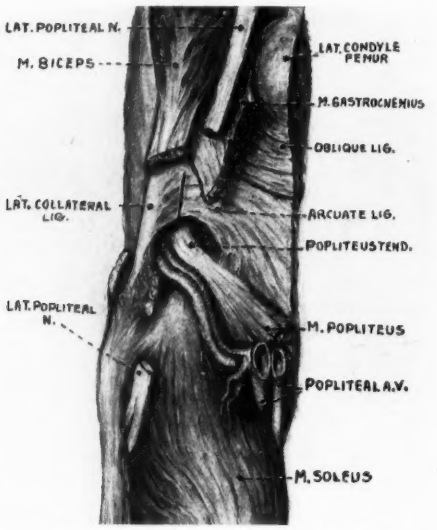


FIG. 4. Lateral half of posterior aspect of the left knee indicating the relation of the arcuate ligament to the lateral collateral ligament and the popliteus tendon and the inferior lateral genicular vessels.

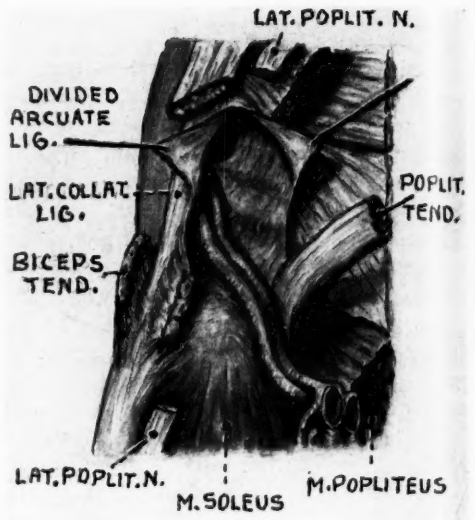


FIG. 5. Same specimen with a longitudinal incision of the arcuate ligament. The popliteus tendon was severed within the joint and pulled out. Incision shows continuity of knee joint cavity with tunnel of popliteal tendon.

The most important structure found under the fascia is the lateral collateral ligament of the knee. This ligament is stretched between the lateral condylar tubercle of the femur and the middle of the lateral surface of the head of the fibula, about 1.5 centimeters anterior to the apex of the head. The fibers of the ligament are frequently arranged in spiral instead of vertical strands.

The insertion of the biceps muscle completely envelops the fibular insertion of the lateral collateral ligament. Between the ligament and the capsule there is a space filled with fatty tissue and sometimes a bursa. The inferior lateral genicular vessels pass horizontally through this space forward from their origin in the popliteal space. Deep to the genicular vessels are the coronary ligament and the lateral meniscus covered by the capsule of the joint. Also covered by the capsule but deep to the lateral collateral ligament and at an angle of about 15 degrees, originating slightly anterior to the lateral collateral ligament, is the popliteus tendon (Fig. 2). In very rare instances, a vertical band of fibers can be observed running from the area of insertion of the extensor digitorum longus across the capsule toward a small area on the femoral condyle in front and below the origin of the popliteus tendon. This is most probably a remnant of a fascial prolongation of the extensor digitorum longus which originates in certain mammals from the femur, instead of the tibia (Fig. 12).

A transverse incision through the fascia lata and capsule of the joint and resection of a part of the lateral collateral ligament show the origin and relation of the popliteus tendon to the ligament, also the relationship of the biceps tendon and lateral collateral ligament (Fig. 3). On the femoral condyle, the popliteus tendon originates in front and below the origin of the lateral collateral ligament. Although these two structures are in close contact, they are actually separated by the capsule of the joint. The popliteus tendon is located in the popliteal groove of the lateral femoral condyle until it reaches the line of the lateral meniscus. The tendon of the popliteus then crosses the lateral meniscus obliquely in a posterior downward direction in a groove of the meniscus. The tendon almost

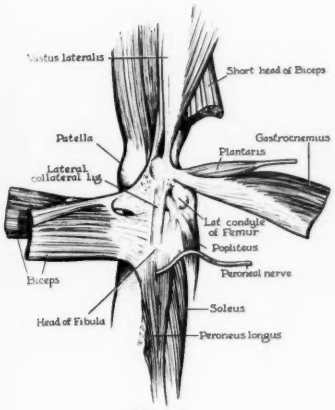


FIG. 6.

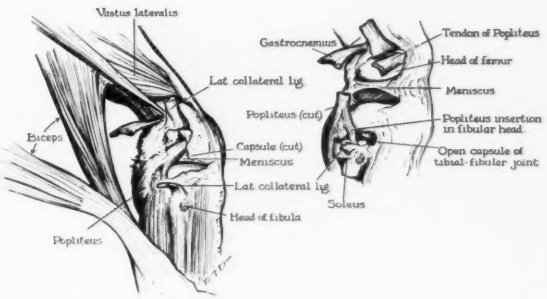


FIG. 7.

FIG. 6. Left knee of a rhesus monkey showing the expansion of the biceps with no actual insertion of the biceps into the fibular head. It also demonstrates the additional tendon of the popliteus to the superior tibiofibular joint.

FIG. 7. Right knee of a chimpanzee showing the insertion of the biceps bypassing the fibular head and the extension of the popliteus tendon into the superior tibiofibular joint.

never adheres to the meniscus (Fig. 4). There is an intimate connection of the popliteus tendon with the fibular head through a ligament connecting both. This connection sometimes reaches the tibiofibular joint, although it is rare in man but occurs regularly in many mammals and, especially, in the chimpanzee, as shown in the illustration of dissection of this area (Figs. 6 and 7). Below this ligament the uppermost fibers of the soleus muscle establish a connection with the popliteus muscle, the fleshy fibers of which appear just above this point and form a triangular muscular body spreading over the posterior part of the tibia (Figs. 10 and 11). The behavior of the popliteus tendon in the transition from full extension to full flexion of the tibia is of great interest. Apparently, the position of the popliteus tendon remains almost unchanged during the excursion from extension to flexion or reversely. The position of the lateral collateral ligament, however, changes so that in full flexion its angle with the popliteus is considerably decreased.

The muscular body of the popliteus, in contrast to the tendon, adheres firmly to the lateral meniscus and the coronary ligament, also to the posterior capsule of the knee joint. This adhesion is effected by means of a thick fascia (popliteal fascia) which covers the muscle and extends into the posterior capsule. The capsule itself adheres to the distal part of the posterior cruciate ligament and the meniscofemoral ligament which crosses the posterior cruciate ligament obliquely upward and medialward. The intimate relation of the popliteus muscle with the meniscus indicates that the contractures of the popliteus muscle produce posterior traction of the meniscus. The comparative immobility of the tendon of the popliteus, adherent to the capsule medial to the lateral collateral ligament, and connections of the tendon to the fibular head, and sometimes with the uppermost fibular origin of the soleus muscle, make the tendon a stabilizer of the knee in all positions. The contractions of the popliteus muscle below the stabilized tendon produce medial rotatory motion of the tibia. This rotation is accompanied by simultaneous posterior traction of the meniscus.

In the lateral exposure of the knee, it is essential to consider that there is insignificant change of position of the popliteus tendon, while the lateral collateral ligament changes

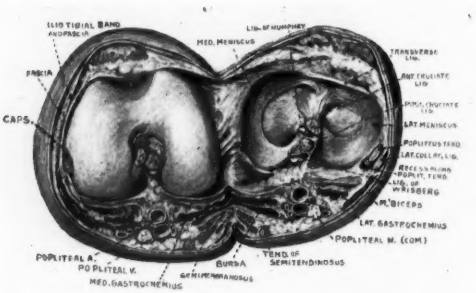


FIG. 8. Right knee joint divided around the periphery, leaving a hinge over medial side of the knee. The knee was opened and shows the relationship of the most important structures. The tunnel of the popliteus tendon is shown divided at the popliteal depression on the lateral meniscus. The proximity of the blood vessels to the posterior capsule can be seen. The separation of the popliteus tendon and lateral collateral ligament is shown. The wall of the popliteal vein is fairly thick. The vein appears first in operations in the posterior part of the knee and can be taken for the artery, which is deeper and more medial.

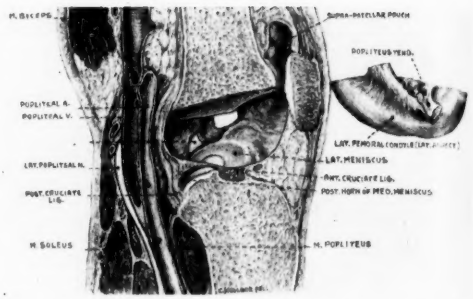


FIG. 9. Left knee joint. Longitudinal axial section of this specimen demonstrates the close relation of the posterior part of the lateral meniscus to the vessels. The lateral condyle was osteotomized and removed from the knee joint. The fragment was rotated and shows its lateral aspect for comparison with the corresponding inner side of the capsule. The joint shows a window in the fascia which was left after separation of the capsule from the origin of the popliteal tendon or of the lateral condyle. The tunnel of the popliteal tendon is also demonstrated in this illustration.

positions with flexion and extension of the tibia. The tendon of the popliteus which remains fixed over the condyle of the femur shifts slightly in the popliteal groove distally and proximally, not exceeding 2 millimeters. The lateral collateral ligament, on the other hand, while fixed on the femoral condyle at its origin, must follow the tibia from 180 degrees' extension to the limit of flexion, not less than about 120 degrees.

Occasionally, although very rarely, in the thickness of the popliteus tendon, there is a sesamoid bone. This is known as the cyamella. It probably is related to the femorofibular disc of the tetrapods and is mostly observed in the popliteus of the eutherian mammals (placental), according to Haines and other anatomists. The possible presence of a cyamella in the tendon of the popliteus should be kept in mind in the surgical exploration of the region for differentiation with the more frequently present fabella in the lateral head of the gastrocnemius. The tendon of the popliteus is adherent on its lateral side to the capsule of the knee joint. When the knee is sectioned in the longitudinal midline and the lateral condyle removed, the adherent part of the tendon leaves a tear in the capsule (Fig. 9). The medial side of the tendon is covered with a synovial membrane which continues over the anterior surface of the popliteus muscle, thus extending the synovial cavity of the knee joint into a space between the popliteus muscle and the posterior surface of the tibia (Figs. 4, 5, 8, 9, and 14). At times, this synovial extension communicates with the superior tibiofibular joint as observed frequently in the knees of the anthropoids (Figs. 6 and 7).

As mentioned before, there is an oblique groove over the lateral surface of the meniscus for the passage of the popliteus tendon. Unless stricken by a pathologic process, the tendon is almost never adherent to the meniscus. The popliteus muscle, on the contrary, is always adherent to the posterior periphery of the lateral meniscus which it moves by contraction. In cases of abnormal thickening of the lateral meniscus, known as discoid meniscus, the contractions of the popliteus in certain positions of the knee are responsible for the exaggerated movement of the meniscus accompanied by an audible click in the knee.

The lateral head of the gastrocnemius muscle originates from the femoral condyle

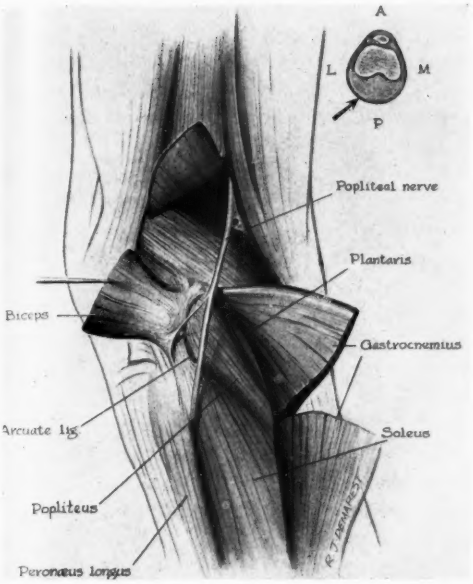


FIG. 10. Lateral aspect of left human knee joint showing arcuate ligament over popliteus muscle, intimate relation of popliteus and soleus. Lateral head of gastrocnemius is lifted from its lateral aspect and sectioned.

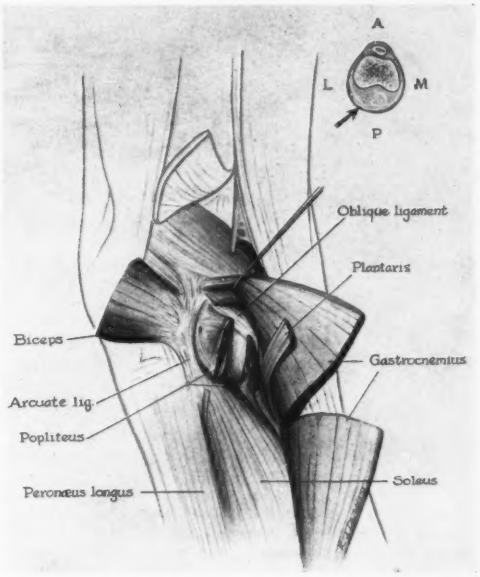


FIG. 11. Same as Figure 10. The popliteus muscle of the left knee is divided to show the posterior capsule and the posterior popliteal oblique ligament (known as the ligament of Winslow).

just above the origin of the lateral collateral ligament and also from the capsule of the joint. The capsule of the joint under the gastrocnemius is very thick. To expose the area of the popliteus muscle and tendon, the lateral head of the gastrocnemius must be forcibly retracted or even sectioned. The relations of the lateral head of the gastrocnemius may be studied better when the gastrocnemius is sectioned partially from the lateral side (Figs. 10 and 11).

The location of the neurovascular hila of muscles, the nerve supply to the tendons, capsule, and periosteum are naturally important. The articular branches to the posterior and lateral components of the knee joint are very abundant. The tibial nerve supplies articular branches to the posterior lateral and medial capsule; the common peroneal nerve supplies the lateral aspect of the knee; and the recurrent peroneal nerve supplies the lateral aspect of the knee and the structures around the tibiofibular joint. The obturator nerve supplies branches to the knee joint through the nervi vasorum of the popliteal artery and vein. All these nerves are avoided in properly placed open, visible incisions. The blood supply of the region in normal cases is well assured by the multiple anastomoses. There is one which is constant and is important; the short biceps is supplied by a branch of the third perforating artery which communicates widely with a branch of the superior lateral genicular. This artery should be avoided. The lateral head of the gastrocnemius is supplied by a branch of the popliteal artery which crosses the popliteal vein, the tibial nerve, and the plantaris muscle and enters the muscle on its deep surface either at the articular line or slightly below, with the nerve, a branch of the common peroneal. The soleus muscle is supplied by a nerve emanating from the common peroneal. Its arterial supply is very abundant.

The popliteus muscle is supplied by many branches: the inferior medial and lateral

FIG. 12. Semischematic. Lateral aspect of left knee showing the anterior tibial tubercle, lateral tibial tubercle, and the apex of the fibular head (3 crosses). The relationship of the meniscus, popliteus tendon, lateral collateral ligament, and biceps muscle seen by transparency. The location of the fibrous extension of the extensor longus digitorum to the femur (very rare in man and not described previously) is shown.

genicular, the nutrient artery of the tibia, and the tibioperoneal trunk. The nerve is derived from the posterior tibial or from the branch supplying the lateral head of the gastrocnemius. Injury to the nerve of the popliteus is apparently not disabling.

The relationship of the large vital structures of the popliteal space (Figs. 8 and 9) create certain hazards in blood surgery over the posterolateral aspect of the knee. In the blind separation of the posterior horn of the lateral meniscus, for instance, usually performed through an anterior incision and under tourniquet hemostasis, an injury to the inferior lateral genicular vessels or even the popliteal artery may be easily overlooked. The inferior lateral geniscular arteries are intimately related to the lateral meniscus and are probably more frequently severed than it is realized. But the consequences of such injury are comparatively unimportant. It is different when the popliteal artery or vein is involved. The distance between the posterior horn of the lateral meniscus and the artery may not exceed 1 centimeter. An inadvertent push of a scalpel or any instrument may easily puncture the posterior capsule and sever or wound the popliteal artery or vein.

In special cases, when a wide exposure of the lateral and posterior aspect of the knee is required, an approach based on the premises outlined in this article may be used.

The patient is placed on the uninvolved side. The knee requiring treatment is placed in extension. An oblique skin incision is made starting slightly proximal to the lateral angle of the base of the patella, the incision runs down in a posterior direction crossing the articular line obliquely, continuing toward the posterior part of the superior tibiofibular joint and the middle of the lateral half of the popliteal space to the longitudinal midline of the space (Fig. 13). The iliotibial line is identified, and the fascia lata is incised from the patella obliquely to the anterior border of the iliotibial band (incision *A*, Fig. 14). Another incision parallel to the skin incision is made from the iliotibial band over the lateral collateral ligament to the biceps tendon (incision *B*, Fig. 14). Through the first incision, the anterior part of the lateral side of the knee is well exposed. The ligamentum mucosum or anterior synovial fold is exposed, also the anterior horn of the lateral meniscus. Through the second incision, the entire lateral periphery of the lateral meniscus, the popliteus tendon, the inferior lateral genicular arteries, and the lateral collateral ligament are freely exposed. The third incision is made parallel to the biceps muscle. The common peroneal nerve is identified behind the tendon of the muscle and retracted laterally. The popliteal space is entered immediately after identification and lateral retraction of the lateral head of the gastrocnemius, between the gastrocnemius and plantaris. The popliteal space is filled with soft, at times, liquefying fat. This fat must be patiently retracted and removed with the realization that nerve branches and blood vessels surrounded by fat are difficult

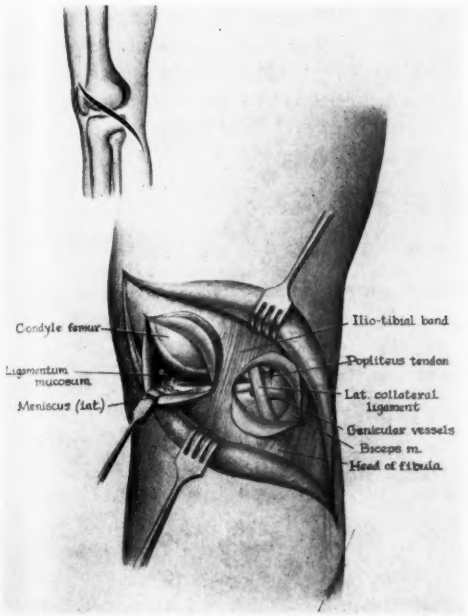


FIG. 13. Left knee. Extended lateroposterior incision. Insert shows skin incision. Two incisions through the fascia in front and behind the iliotibia band. These two incisions can be converted into one if necessary. Part of the arcuate ligament shown deep to the genicular vessels.

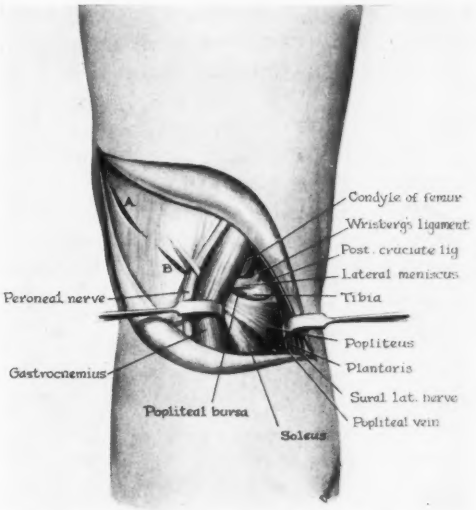


FIG. 14. The third part of the incision behind the biceps shown. With the proper retraction of the biceps and peroneal nerve and the lateral head which can be transsected if necessary, the posterior capsule can be exposed. A transverse incision of the capsule just above the popliteus muscle from the midline to the popliteus tendon uncovers the lateral meniscus, the posterior cruciate, the meniscofemoral ligament and the popliteus bursa extending toward the tibia in front of the popliteus muscle. Knee must be in extension when posterior capsule is incised.

to recognize. With proper precautions, these difficulties are rapidly overcome. The plantaris muscle is retracted medially with the large blood vessels and the tibial nerve; the lateral sural nerve is found immediately under the fascia and is retracted with the plantaris. The only important vessels crossing the operative field are the inferior lateral genicular, which can be easily divided to clear the field. This permits deep access to the posterior capsule of the joint where the arcuate ligament and the popliteus muscle may be identified. Upon identification of the popliteus muscle, a transverse incision is made into the capsule of the joint parallel to the superior margin of the popliteus muscle from the midline to the junction of the tendon and a part of the capsule may even be excised. If necessary, the lateral head of the gastrocnemius may be divided at this level. All three incisions can now be used for complete exploration of the knee. If it is necessary, the iliotibial band may be divided, uniting incision *A* and *B*. In this case, it is imperative to safeguard the lateral collateral ligament and the popliteus tendon. On the other hand, the lateral collateral ligament may be sacrificed but then, as described before, the iliotibial band must be left intact. This exposure is described for the knee in extension. Very slight flexion may relax the structure for better retraction. In full flexion, however, the relationship of the collateral ligament and the popliteus change; also, it is more difficult to expose the popliteal vessels which recede into the depth of the wound. The exposure of the nerve branches becomes more difficult on account of relaxation of the tension in the popliteal fat—the bane of good exposure.

This incision is profitably used in various instances but is especially applicable in re-

moval of multiple osteochondral bodies of the knee in osteochondromatosis and also in removal of difficult discoid menisci.

SUMMARY

1. Principles of an adequate approach to the knee joint are discussed.

2. Broader aspects of function and morphology are debated in reference to surgical approaches to the lateral side of the knee joint.

3. The characteristics of the important structures—lateral collateral ligament, popliteus tendon, lateral meniscus, biceps tendon, and iliotibial band—are given.

4. An extended lateroposterior approach to the knee is described.

REFERENCES

1. Furst, K. M. Der Musculus popliteus und seine Sehne. Lund: Malmströms Buchdrukerei, 1903.
2. Haines, R. W. The tetrapod knee joint. J. Anat., Lond., 1941-1942, 76: 270-301.

CARCINOMA OF THE MAJOR INTRAHEPATIC AND THE EXTRAHEPATIC BILE DUCTS EXCLUSIVE OF THE PAPILLA OF VATER

KAMAL KUWAYTI, M.D., ARCHIE H. BAGGENSTOSS, M.D.,
MAURICE H. STAUFFER, M.D., and JAMES T. PRIESTLEY, M.D., F.A.C.S.,
Rochester, Minnesota

THIS REPORT deals with primary carcinoma of the extrahepatic bile ducts and the major intrahepatic bile ducts, namely, left and right hepatic, common hepatic, cystic, and common bile ducts. Carcinoma which arises from small radicals of the intrahepatic bile ducts was not included because of its similarity to primary carcinoma of the hepatic parenchyma. Likewise, carcinoma of the papilla of Vater was not included because of the difficulty of determining with certainty the exact site of origin in some of these cases.

HISTORICAL BACKGROUND

Renshaw credited Durand-Fardel with recognition of carcinoma of the common duct and with report of the first case in 1840. He also attributed the first description of carcinoma of the hepatic ducts to Schueppel in 1878. Musser, in 1889, wrote what is probably the first comprehensive review on the subject and reported 18 cases including 3 cases of carcinoma of the papilla of Vater. W. J. Mayo, in 1903, reported 6 cases of primary carcinoma of the ducts observed in 511 operations on the biliary tract.

Since that time reports have appeared with increasing frequency. With few exceptions, however, these reports reviewed carcinoma of the bile ducts together with carcinoma of the gallbladder, and there was little attempt to separate these cases from carcinoma of the papilla of Vater. Stewart, Lieber, and Morgan in 1940 were the first to write an extensive review on the subject. They carried out an analysis of all the cases reported in the literature, debated the authenticity of the majority of them, and added 6 cases of their own. Reports based on findings at operation have been made by Marshall, Judd and Gray, Gray and Sharpe, and Neibling, Dockerty, and Waugh. Since such studies do not provide complete data as to the exact location, extension, or incidence of metastasis, it was thought worth while to review our observations at necropsy.

MATERIAL AND METHOD

During the 39 year period extending from 1915 to 1953 inclusive, there were 63 cases in which a diagnosis of carcinoma of the bile ducts was recorded in the necropsy records of the Mayo Clinic. The clinical records, necropsy protocols, histologic sections of various organs, and photographs of these cases were carefully reviewed. In some instances in which the material available proved insufficient, the preserved gross specimens were re-examined and new histologic sections made. These 63 cases form the basis of this study.

GENERAL OBSERVATIONS

Incidence. The 63 cases presented herein were chosen from the protocols of 24,029 consecutive necropsies for the period 1915 to 1953 inclusive. Thus, the incidence was 1

From the Sections of Pathologic Anatomy, Medicine, and Surgery, Mayo Clinic and the Mayo Foundation, Rochester, Minnesota.

Abridgment of thesis submitted by Dr. Kuwayti to the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Medicine.

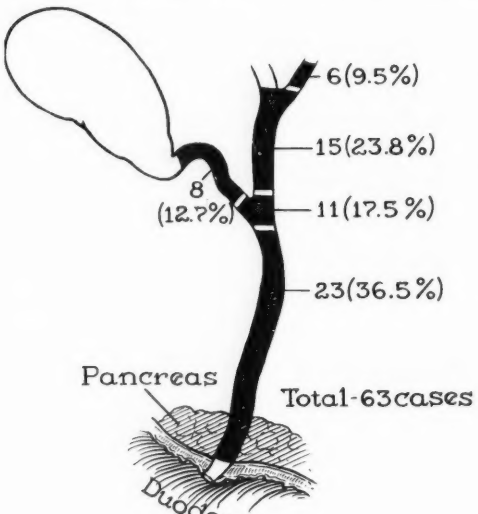


FIG. 1. Distribution of cases according to site of carcinoma in bile ducts.

case of bile duct carcinoma per 381 necropsies (0.26 per cent), which compares with incidences ranging from 0.089 to 0.42 reported by other workers.

The sites of origin of the primary carcinomatous lesions that obstructed biliary flow were determined from the necropsy records of the Mayo Clinic for the 10 year period 1943 to 1952 inclusive and were as follows: the head of the pancreas in 67 cases, the gallbladder in 32, the bile ducts (this study) in 24, and the papilla of Vater in 20. These figures show that the bile ducts ranked third as a site of origin.

Anatomic location. Six of the 63 lesions that form the basis for this report were located in the left hepatic duct, 15 in the common hepatic duct, 8 in the cystic duct, 11 at the juncture of the common hepatic, cystic, and common bile ducts, and 23 in the common bile duct distal to the juncture (Fig. 1). In no instance could the lesion be traced to the right hepatic duct.

TABLE I.—INCIDENCE OF PALPABLE LIVER AND GALLBLADDER

	Cases		
Location of carcinoma	*Total*	*Palpable liver*	*Palpable gallbladder*
Left hepatic duct	6	4	—
Common hepatic duct	15	13	3
Cystic duct	8	8	4
Juncture of cystic and common ducts	11	9	2
Common bile duct	23	19	9
Totals: No.	63	53	18
Per cent		84	31.5*

*Based on patients who had not undergone cholecystectomy.

Sex and age. There were 46 men and 17 women, a ratio of men to women of 2.7 to 1, or approximately 73 per cent men and 27 per cent women. This is a slightly higher proportion of men than has been reported by other investigators. The corresponding ratio for the entire necropsy series for the period covered by this study was 1.9 to 1.

The distribution of the patients according to age and sex is shown in Figure 2. It is to be noted that 71.4 per cent of all the patients were in the sixth and seventh decades of life. The average age was 62.2 years for men and 60.7 years for women. The youngest patient was a 40 year old man and the oldest, an 81 year old man. These figures agree with those of other investigators. The youngest patient reported in the literature, however, is a 23 year old woman and the oldest is probably an 86 year old man.

CLINICAL FEATURES

Symptoms. The major symptoms relative to the present illness which the 63 patients presented at the time of registration were as follows: jaundice in 96.8 per cent; loss of weight in 95 per cent; pruritus in 88.5 per cent; anorexia in 74 per cent; dark urine in 63 per cent; clay-colored stools in 62 per cent; abdominal pain in 57 per cent; weakness in 44.5 per cent; fever in 14 per cent; diarrhea in 13 per cent; and chills in 9 per cent. Sixty-one patients complained of jaundice (96.8 per cent). Jaundice developed in the remaining 2 patients while they were under observation in the hospital. It was the chief complaint in the great majority of cases. It varied in degree in different patients but in most of them it was marked.

Twenty-eight of the 61 patients who had jaundice on admission gave a definite statement as to whether the jaundice showed

some fluctuation or was progressive. Of these, 58 per cent noted that the jaundice fluctuated prior to the time they came for examination. This is entirely a subjective observation, not always valid, but it might throw some light on the early course of the disease. In the remainder, 42 per cent, the jaundice was stationary or progressive.

Loss of weight had occurred in 58 patients, it had not occurred in 3, and information on this point was not recorded in 2; thus 95 per cent of the patients on whom information was available had lost weight. The amount of weight lost varied greatly from one patient to another, but in the majority it occurred early and in some instances it even preceded the detection of jaundice by the patient or the relatives. The average loss was 27 pounds. One patient had actually gained weight.

Fifty-one per cent of the patients gave a history of previous abdominal pain. In 17.5 per cent of the cases this pain was suggestive of biliary colic. In the remaining 33.5 per cent the symptom of pain was vaguely described and consisted of dyspepsia, "indigestion," "gas," or occasional abdominal discomfort. Forty-nine per cent of the patients were free of any previous abdominal pain.

A total of 57 per cent complained of abdominal pain associated with their present illness. In 13 per cent pain preceded jaundice and disappeared after the jaundice appeared, while in 44 per cent abdominal pain was present throughout the present illness. In most of these patients the pain was mild and was localized in the epigastrium or below the right costal margin. A few required analgesia and sedation.

Duration of symptoms. Because of their insidious onset, determination of the duration of symptoms in carcinoma is difficult. To study this aspect of the disease the 63 patients were divided into two groups; namely, 47 patients who had surgical treatment and 16 patients who did not have surgical treatment. Patients in the first group had various surgical procedures ranging from simple exploration and biopsy to radical resection. In this group, the average duration of symptoms until the time of surgical intervention was 10 weeks, the range being 2 to 42 weeks. In the second group, the disease presumably ran its natural course. The duration of symptoms ranged from 2 to 38 weeks, the average being 14 weeks.

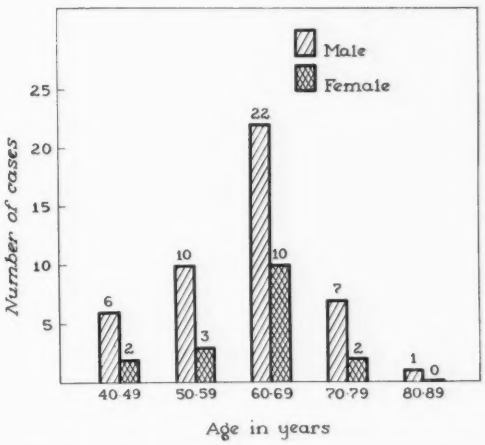


FIG. 2. Distribution of patients according to age and sex.

Physical findings. The liver was palpable in 84 per cent of the cases (Table I). With few exceptions, it generally was not tender to deep palpation and it rarely was nodular. In the majority of patients the edge of the liver was felt 2 to 4 fingerbreadths below the right costal margin at the midclavicular line; in a few the edge was just barely palpable and in some it reached the umbilicus. The gallbladder was clinically palpable in 31.5 per cent of the patients who had not undergone cholecystectomy (Table I). Nine

TABLE II.—CONCENTRATION OF SERUM BILIRUBIN

Location of carcinoma	*Total serum bilirubin, mgm. per 100 c.c.*			*Patients with*		
	Lowest reading	*Highest reading*	*Average*	*Serial determinations*	*Fluctuation of jaundice*	*Progression of jaundice*
Left hepatic duct	4.1	28.4	17.4	3	3	—
Common hepatic duct	6.3	53.6	21.5	13	6	7
Cystic duct	8.2	74.8	32.7	6	5	1
Juncture of cystic and common ducts	7.9	152.7	46.0	7	5	2
Common bile duct	6.6	55.5	24.5	15	7	8
Total			27.3	44	26	18

of the 18 patients with palpable gallbladder also had gallstones.

Laboratory findings. The level of total serum bilirubin varied greatly in these cases (Table II). No definite relation between the level of serum bilirubin and the location of the carcinoma could be found. The over-all average value for total serum bilirubin was 27.3 milligrams per 100 cubic centimeters. The lowest level in this series, 4.1 milligrams per 100 cubic centimeters, was in a case of carcinoma of the left hepatic duct, and the highest, 152.7 milligrams per 100 cubic centimeters, was in a case of carcinoma at the juncture of the cystic and common hepatic ducts. In all cases, the highest value was for the direct-reacting portion.

The records of 44 patients who had serial determinations of serum bilirubin were studied to see whether the jaundice was fluctuant or progressive. The jaundice was considered fluctuant whenever the values for total serum bilirubin, in milligrams per 100 cubic centimeters, varied at least 2 milligrams in cases in which they were less than 10, at least 3 milligrams in cases in which they were in the range of 10 to 20 inclusive, and at least 4 milligrams in cases in which they were more than 20. Smaller variations were considered to fall within the margin of technical error. On the basis of these criteria the jaundice was found to fluctuate in approximately 60 per cent of the cases (Table II).

Duodenal aspiration was performed in 42 patients. Five of these patients had bile in the duodenal contents in significant amount, 14 had only a trace of bile, and the remaining 23 had no bile. Two of the 42 patients had a significant amount of blood in the duodenal contents, 12 had only a trace, and the remaining 28 had none. Since a trace of bile or blood is not considered clinically of much importance, it can be concluded that bile and blood were present in the duodenal contents in significant amounts in 12 per cent and 5 per cent of the cases respectively. The fact that the majority of patients who underwent this test had multiple duodenal aspirations made the margin of error negligible. Bile was present in the duodenum only in the cases in which the jaundice was fluctuant.

Prior to 1945 the Schmidt qualitative test for fecal urobilinogen was done in 23 cases, more than 1 determination being made in the majority of them; the results were negative in 21 cases and positive in 2 cases. Quantitative determination of this substance in 48 hour and 72 hour stools was made in 5 other cases; the amount found was less than 5 milligrams per 24 hours in 2 cases and more than 5 milligrams in 3 cases. The actual values in the last-mentioned group were 8, 8.3, and 11.5 milligrams per 24 hours respectively.

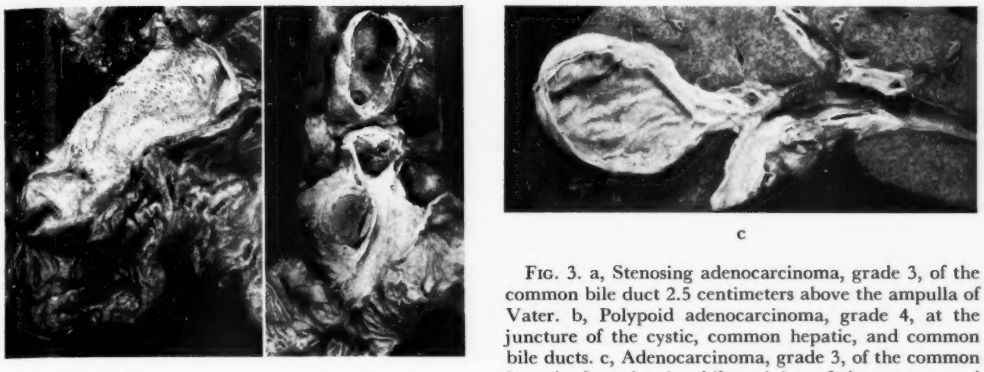
The cephalin-cholesterol flocculation test was performed in 12 cases. Negative results were obtained in 10 cases and a value of 2+ units was obtained in 2 cases. The thymol turbidity test was done in 13 cases. In 11 of these the reading was between 0 and 4 units and in 2 it was 5 and 8 units respectively. In the last 2 cases concomitant cholangitis and hepatic abscesses were present. Alkaline phosphatase, determined in 11 cases, was increased in all but 2 cases, the values ranging from 11.1 to 47.7 Bodansky units; the average value was 26.2 Bodansky units.

Prothrombin time was determined in 28 cases; the remaining 35 cases occurred in the period before the test was introduced. Fifteen of the 28 patients had repeatedly normal readings, and 13 had greatly increased readings, but all responded to vitamin K therapy.

Anemia was considered to be present when the concentration of hemoglobin per 100 cubic centimeters of blood was less than 10 grams in women and 13 grams in men. On this basis, anemia was present in 43 per cent of the cases. It was not severe in the majority of cases, and it occurred in some patients who had concomitant hemorrhage at various sites, for example, bleeding from a duodenal or gastric ulcer, or uterine bleeding.

PATHOLOGIC FEATURES

Gross appearance. The primary lesion was often small. It is apparent that these rel-



a b c

FIG. 3. a, Stenosing adenocarcinoma, grade 3, of the common bile duct 2.5 centimeters above the ampulla of Vater. b, Polypoid adenocarcinoma, grade 4, at the juncture of the cystic, common hepatic, and common bile ducts. c, Adenocarcinoma, grade 3, of the common hepatic duct showing bile staining of the mucosa and dilatation of the duct proximal to the growth.

tively small carcinomas, because of their strategic location and the size of the structures involved, caused symptoms and death early in the course of their development. The growth usually involved the whole thickness of the wall of the duct. In a large number of cases it formed a nodular thickening of the wall with distortion of the mucosa (Fig. 3a). In some cases the neoplasm tended to encircle the wall, forming an annular stricture. It diffusely infiltrated the surrounding structures in the portal fissure in many cases to form a bulky, stony-hard mass. In rare instances the growth projected into the lumen of the bile duct in the form of a large polypoid mass (Fig. 3b). Ulceration and necrosis occurred in these situations. In some cases it tended to extend along the wall of the duct and convert varying segments of it into a hard, rigid tube. Stenosis of varying degrees or complete obstruction of the lumen eventually occurred in all the cases. Above the point of obstruction, whether complete or incomplete, the mucosa appeared grossly bile stained while distally it was often whitish (Fig. 3c). The duct proximal to the growth was almost always dilated, sometimes several times normal (Fig. 3a and c).

The location of the carcinoma in the different segments of the bile ducts played a prominent role in the behavior of the growth. The only 2 locations where the carcinoma remained confined to the site of origin were the common bile duct distal to the juncture of the cystic and common hepatic ducts and, to a lesser extent, in the common hepatic duct. A tumor in the left hepatic duct tended to extend to the common hepatic duct and right hepatic duct in all the cases. All carcinomas of the cystic duct extended distally to involve the neck of the gallbladder or proximally to involve the common bile duct, or in both directions. Carcinoma at the juncture of the cystic, common hepatic, and common bile ducts by definition involved the three ducts for varying distances. These sites of spread were all confirmed by histologic sections.

Complete anatomic obstruction of the duct by carcinoma was studied carefully. In some cases the patency of the involved duct was readily demonstrable, but in a few cases in which complete obstruction was suspected at first glance patency had to be demonstrated by passage of a fine probe through the site of stenosis. Complete anatomic obstruction occurred in only 34 per cent of the cases.

Spread and metastasis. Metastasis or direct spread or both occurred in 45 cases (71.4 per cent) as follows: to the liver in 21 cases; the regional lymph nodes in 21 cases; the peritoneal surface of the gastrointestinal tract in 11 cases; the aortic lymph nodes in 8 cases; the gallbladder in 8 cases; the pancreas,

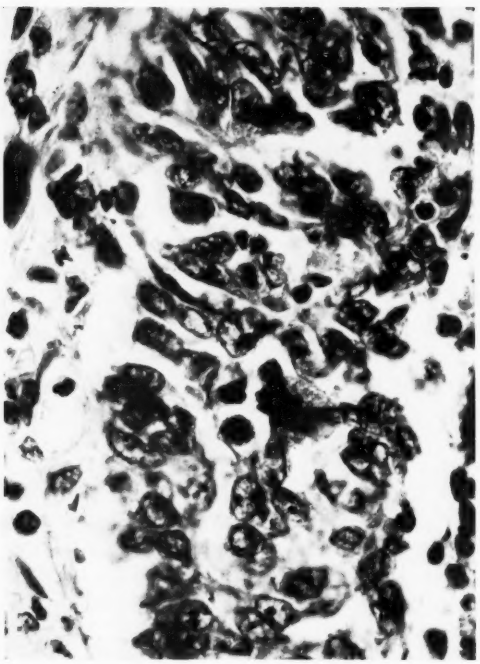


FIG. 4. Grade 4 adenocarcinoma at the juncture of the cystic, common hepatic, and common bile ducts. The lesion is highly cellular and contains abnormal mitotic figures. Hematoxylin and eosin, ×600.

head and tail in 7 cases; the pouch of Douglas in 6 cases; the peripancreatic lymph nodes in 3 cases; the mesentery in 3 cases; the adrenals in 3 cases; the lungs in 3 cases. Spread to adjacent structures alone accounted for 17.5 per cent of all cases. This figure does not include local spread by continuity to other segments of the bile ducts. The incidence of metastatic spread reported by other observers varied from 46 to 92 per cent.

Histologic appearance. All the lesions were studied histologically and graded as to degree of malignancy by the Broders method. Grade 1 and 4 lesions were extremely rare (3 per cent each). Most of the lesions were of grade 3, comprising 56 per cent of the cases. Grade 2 carcinoma occurred in the remaining 38 per cent of the cases.

All the lesions in this study were adenocarcinomas. Squamous cell carcinoma has been reported by Cabot but none was found in this study. The appearance and degree of differentiation of the cells varied widely. They were composed of irregular acini lined by tall columnar epithelium in various stages of differentiation; these cells contained spherical or ovoid, hyperchromatic basal nuclei. Most of the nuclei had multiple nucleoli. The cytoplasm was usually moderate in amount, eosinophilic, and granular. Occasional vacuolation of the cytoplasm was noted. The amount of mitosis correlated well with the degree of anaplasia. Abnormal mitotic figures were seen in the highly undifferentiated lesions (Fig. 4). The lining cells of the acini were sometimes piled up in several layers; many were mucus-secreting. Occasionally marked dilatation of the lumen and distention with mucus were noted (Fig. 5a). In some of these dilated acini, the lining neoplastic cells tended to be short columnar or even cuboidal.

In all the cases there was a variable tendency toward invasion of the different layers of the duct wall (Fig. 5b). Carcinoma of the left hepatic duct tended to spread and invade the surrounding hepatic parenchyma.

The amount of fibrous stroma separating the neoplastic glandular structures varied greatly. Some of the carcinomas were highly cellular and contained scanty stroma (Fig. 5b). In other cases, the amount of stroma was large, forming scirrhous lesions. Occasional small collections of lymphocytes were encountered. Necrosis and infiltration with polymorphonuclear leucocytes were seen in some cases, especially in those in which the lesion was polypoid and projected into the lumen of the duct.

In 3 cases the lesions were papillary adenocarcinomas (Fig. 5c). In 4 additional cases, the lesions showed a tendency toward papillary formation in some parts of the section.

Special efforts were made to examine the nerve filaments in the sections. Nerve bundles were seen in all but 3 cases. The perineural lymphatic space was invaded in 36 cases (Fig. 5d). In 11 of the 36 cases there was additional intraneural spread, and in 1

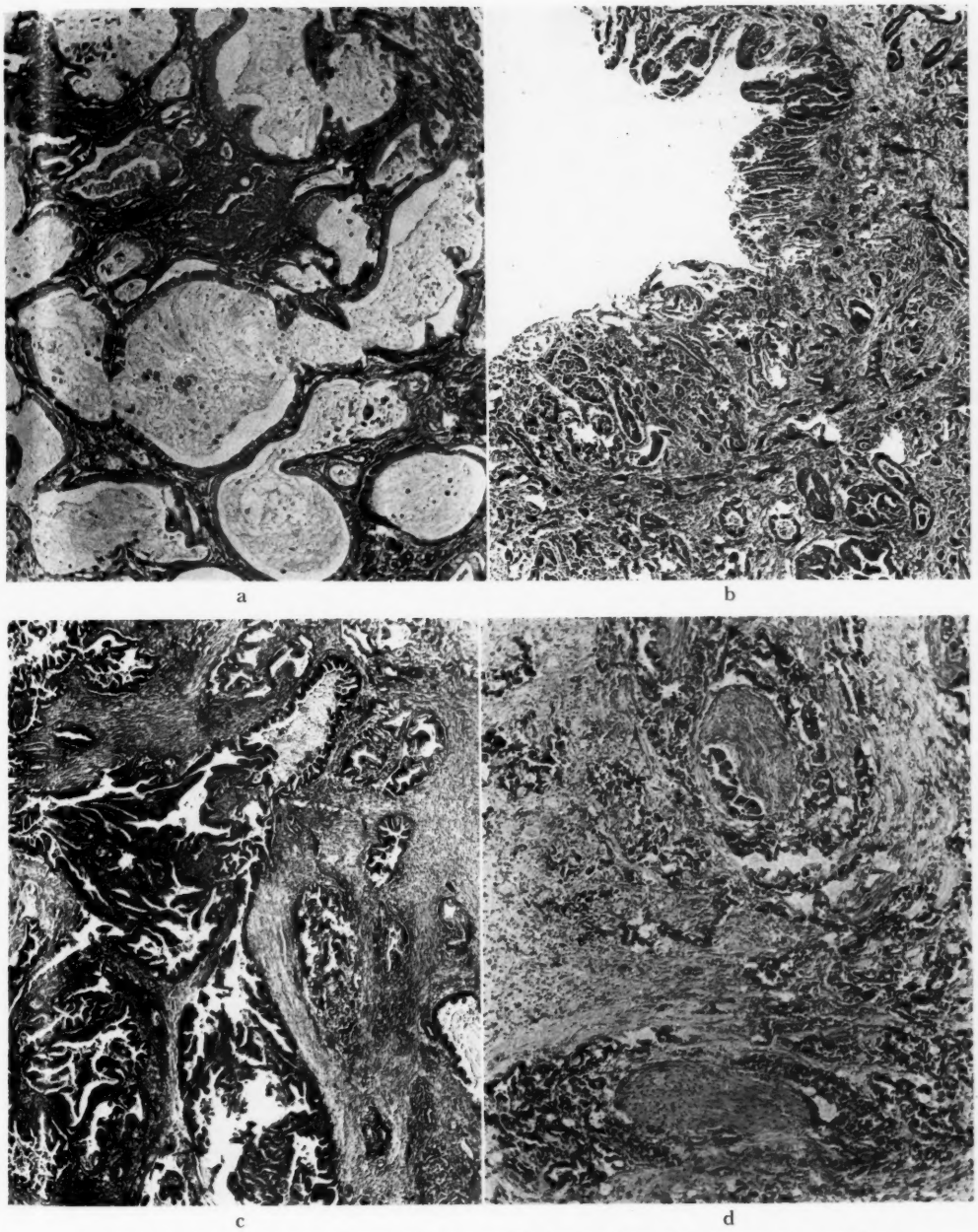


FIG. 5. a, Grade 2 adenocarcinoma of the common hepatic duct. The lumens of the acini are filled and distended with mucus. Hematoxylin and eosin, ×50. b, Grade 3 adenocarcinoma of the common bile duct showing involvement of the mucosa and the underlying ductal wall. Hematoxylin and eosin, ×30. c, Grade 2 papillary adenocarcinoma of the common bile duct. Hematoxylin and eosin, ×30. d, Grade 3 adenocarcinoma at the juncture of the cystic, common hepatic, and common bile ducts showing invasion of nerves. Hematoxylin and eosin, ×50.

case the nerve itself was invaded but the perineural space was free. The nerves were intact in the remaining 23 cases. Thus, the over-all incidence of nerve invasion by carcinoma cells was 61.7 per cent.

Incidence of cholelithiasis. Twenty-six patients had stones in the biliary tract (41.3 per cent). In 7 of these cases there was a history of cholelithiasis. Six of these patients had undergone cholecystectomy and the other patient had undergone cholecystostomy for removal of stones from the gallbladder. Six patients had stones in the common bile duct; 1 of these also had a stone in the cystic duct, and another had a stone in the common hepatic duct. In all these instances the associated ductal stones were either at, or proximal to, the site of carcinoma.

Secondary effects. The liver was the seat of various changes secondary to biliary obstruction due to the carcinoma. Its color at necropsy was usually intense green. The outer surface was smooth or finely granular, and the cut surface usually was wet with excess bile and showed increased lobular markings. The consistency was often firmer than usual. Histologically, the bile canaliculi, especially in the central parts of the lobules, were filled with bile. In some instances the severity of the biliary stasis was indicated by the presence of bile lakes. There was associated central necrosis of the liver cells in 7 cases.

The weight of the liver was known in 54 cases. It was of normal size (1,500 to 2,000 gm.) in 11 cases, large (more than 2,000 gm.) in 31, and small (less than 1,500 gm.) in 12. Atrophy of the left lobe of the liver occurred in 4 cases of carcinoma of the left hepatic duct and in an additional case of carcinoma of the common hepatic duct in which the lesion extended to the left hepatic duct. Consequent to biliary obstruction there were varying degrees of dilatation of the intrahepatic ducts in almost all the cases. In some of these the dilatation was marked (severe cholangiectasis or hydrohepatosis). Suppurative cholangitis was superadded to the aforementioned changes in 7 cases (11 per cent). Several types of abscesses were encountered: multiple abscesses probably a consequence of ascending cholangitis, 7 cases; subdiaphragmatic abscess possibly an extension from an intrahepatic abscess, 1 case; miliary abscesses due to septicemia, 1 case; and pericholecystic abscess of the liver, 1 case. The abscess of the liver ruptured in 1 case and produced bile peritonitis. Three cases of biliary cirrhosis were encountered. In 2 of these cases the cirrhosis was early. Periportal fibrosis was found in 8 cases (12.7 per cent). In some cases (24 per cent) the hepatic lesions were so severe that they led to a clinical diagnosis of hepatic insufficiency and coma. Changes in the gallbladder were difficult to interpret because in most cases some type of operation had been performed on it.

Numerous other findings were noted in various organs of the body. Of particular interest was the occurrence of splenomegaly (more than 250 gm.) in 25 cases (40 per cent) and mild esophageal varices in 1 case.

COMMENT

In this series of cases jaundice was the most important symptom and was present in all the cases. Although obstructive jaundice resulting from malignant neoplasm is often said to run a characteristic painless course, pain was absent in 43 per cent of our cases. Pain, when present, however, ceased after the appearance of jaundice in 13 per cent of the cases. Loss of weight, pruritus, and anorexia occurred in a high percentage of cases, while chills and fever occurred rather infrequently.

Fluctuation of the concentration of serum bilirubin is said to occur in only 10 per cent of the cases of neoplastic biliary obstruction. Sixty per cent of 44 patients in this study who had serial determinations of serum bilirubin showed fluctuation of jaundice. All who had clinically fluctuant jaundice were found to have incomplete anatomic obstruction of the duct. On the other hand, in some cases in which occlusion was incomplete the jaundice was steady or increased. In such cases a

functional occlusion may occur as a result of associated edema and inflammation of the duct wall or spasm of the smooth muscle.

From the pathologic point of view, some observations were prominent. These neoplastic lesions tended to spread by local extension to neighboring segments of the biliary tract. They also metastasized to other organs early in their course. The over-all incidence of metastasis was 71.4 per cent. It may be mentioned that although in some cases the original lesion was small and gross evidence of metastasis was lacking, subsequent histologic examination revealed involvement of the regional lymph nodes and other organs.

The grading of the malignancy of the lesions by the Broders method was of interest in that neither of the 2 patients with grade 1 carcinoma had any metastasis while the 2 with grade 4 carcinoma did have metastasis. The incidence of metastasis was 80 per cent for grade 3 lesions and 62.5 per cent for grade 2 lesions.

Neibling, Dockerty, and Waugh did not find any correlation between involvement of nerves and metastasis, but pain occurred more frequently in cases in which the nerves were affected by carcinoma cells than in other cases. This aspect of the disease was studied in the present series and some relation was found between incidence of nerve involvement and pain or metastasis. Among 37 patients who had involvement of nerves, there were 22 who had pain during the course of their disease, the remaining 15 being free of pain. Thirty of these same patients presented evidence of metastasis while 7 did not. Conversely, among 23 patients who did not have involvement of the nerves only 10 had pain and 13 did not. Of these same patients 14 had metastasis and 9 had none. Serial sections were not made, which are probably essential for a true evaluation of this phase of the problem in the cases in which nerves show lack of involvement by carcinoma.

The frequency with which gallstones are associated with choledochal carcinoma varies as reported by different observers. The incidence of stones in our cases was 41.3 per cent compared with incidences of 11 to 57 per cent reported by other observers. This high incidence led to the belief that there is an etiologic relationship between the two conditions. The only apparent factor favoring the theory that stones act to incite the development of ductal carcinoma is this high rate of association. Certain observations, however, tend to contradict this theory; for example, stones were present in women as compared with men in the ratio of about 2 to 1. This ratio was even higher in the series reported by Neibling, Dockerty, and Waugh. This ratio is in marked contrast to the incidence of ductal carcinoma, which is higher in men. It is noted that the group of cases of carcinoma at the juncture of the cystic and common ducts consisted only of men, and that only 1 patient had gallstones—an incidence of about 9 per cent. For the most part, the higher incidence of carcinoma in other parts of the bile ducts is attributable to the cases in women.

In 7 cases stones were removed months or years before the diagnosis of carcinoma was made. One of these patients, a 73 year old woman, underwent cholecystectomy in May 1920 for acute purulent cholecystitis with stones. She returned in November 1920 because of recurrent pain, and a stone was removed from the common bile duct. She returned again in 1923, at which time she had carcinoma of the stump of the cystic duct. No more stones were found at necropsy. In cases such as this, it is difficult to explain any relationship between the occurrence of stones and the development of carcinoma.

The question also arises as to how many of these stones seen in carcinoma of the ducts are formed after the development of the neoplasm which causes obstruction, stasis of bile, and infection, all factors of importance in stone formation. The exact relationship between biliary calculi and neoplasms of the bile ducts remains undetermined.

Ascites was found in 16 cases (25.4 per cent). The mechanism of ascites in these cases may be based on a combination of

several factors such as carcinomatosis of the peritoneum or mesentery, obstruction of the portal vein by neoplasm, thrombosis of portal or hepatic veins, cirrhosis of the liver, and hypoproteinemia. With 1 exception, the presence of ascites was not discovered clinically but was a finding at operation or necropsy. This observation is in agreement with that of other authors.

SUMMARY

The clinical and pathologic features of 63 cases of carcinoma of the major intrahepatic and the extrahepatic bile ducts studied at necropsy at the Mayo Clinic for the period 1915 to 1953 inclusive are presented.

The disease occurred 2.7 times as frequently in men as in women. More patients of either sex were in the seventh decade of life than in any other. Among the major symptoms and signs, jaundice was a universal finding while loss of weight, pruritus, anorexia, palpable liver, and abdominal pain occurred in the majority of patients. The jaundice fluctuated in 60 per cent of the patients who had serial determinations of serum bilirubin. The value for total serum bilirubin averaged 27.3 milligrams per 100 cubic centimeters. Duodenal aspiration revealed absence of bile in the duodenal contents in 88 per cent of the cases, while blood was present in 5 per cent.

All the lesions were adenocarcinomas, the majority of which were of grade 3 malignancy (Broders method). The primary lesion was often small, producing complete anatomic obstruction in only 34 per cent of the cases. There was, however, a tendency toward early spread by local extension and distant metastasis, which occurred in 71.4 per cent of the cases. The incidence of metastasis was proportionate to the degree of anaplasia.

The disease was rapidly fatal, leading to death in an average of 14 weeks after first symptoms in the patients who had no surgical intervention. Hepatic failure with coma was the terminal event in 24 per cent of the cases.

REFERENCES

1. Broders, A. C. The microscopic grading of cancer. In: Treatment of Cancer and Allied Diseases by Pack, G. T., and Livingston, E. M. Pp. 19–41. Vol. I. New York: Paul B. Hoeber, Inc., 1940.
2. Cabot, R. C. Case records of the Massachusetts General Hospital. N. England J. M., 1930, 202: 1260–1262.
3. Gray, H. K., and Sharpe, W. S. Carcinoma of the gallbladder, extrahepatic bile ducts, and the major duodenal papilla. Surg. Clin. N. America, August, 1941, pp. 1117–1127.
4. Judd, E. S., and Gray, H. K. Carcinoma of the gallbladder and bile duct. Surg. Gyn. Obst., 1932, 55: 308–315.
5. Marshall, J. M. Tumors of the bile ducts. Surg. Gyn. Obst., 1932, 54: 6–12.
6. Mayo, W. J. Malignant disease of the common bile duct. Northwest M., 1903, 1: 173–177.
7. Musser, J. H. Primary cancer of the gall-bladder and bile-ducts. Boston M. & S. J., 1889, 121: 525–529; 581–583.
8. Neibling, H. A., Dockerty, M. B., and Waugh, J. M. Carcinoma of the extrahepatic bile ducts. Surg. Gyn. Obst., 1949, 89: 429–438.
9. Renshaw, Kinsley. Malignant neoplasms of the extrahepatic biliary ducts. Ann. Surg., 1922, 76: 205–221.
10. Stewart, H. L., Lieber, M. M., and Morgan, D. R. Carcinoma of the extrahepatic bile ducts. Arch. Surg., 1940, 41: 662–713.

EDITORIALS

INDUCED HYPOTENSION

DAVID M. LITTLE, JR., M.D., Hartford, Connecticut

THE PROBLEM OF BLEEDING during operative intervention has assumed an increasing importance during the last several years, due to the fact that certain surgical procedures are now so vastly extensive and that other operations involve penetration into vital structures of the body. A number of workers have suggested that one effective method of controlling either gross surgical hemorrhage or excessive vascular ooze would be the reduction of systemic arterial blood pressure. A variety of techniques has been evolved to produce such an intentional hypotension. When the effects of postural ischemia, attained by the proper positioning of the patient upon the operating table with the area of operation superior to the rest of the body, are combined with induced hypotension, it has been possible to provide operative conditions which have been clearly beneficial in facilitating surgical technique.

The factors of immediate concern in controlling blood pressure are cardiac output, total volume of circulating blood, peripheral resistance, viscosity of the blood, and elasticity of the large arteries. The elasticity of the walls of the large arteries is a morphologic entity which remains relatively unalterable, certainly during the short span of a surgical procedure. The viscosity of the blood fluctuates constantly during anesthesia and operation, changing with variations in chemical composition, temperature, and content of gas, colloids, and suspended corpuscles; but these changes are not amenable to control for the purpose of inducing hypotension. A decreased cardiac output, of course, will produce hypotension and it is important to realize that the reverse is also true—decreased cardiac output is an unavoidable concomitant of induced hypotension. It has been sought intentionally as a means of producing hypotension by only a handful of exceedingly bold workers.

Intentional hypotension has been produced most frequently either by reduction of the total volume of circulating blood or by a decrease in peripheral resistance. A decade ago, Gardner introduced the technique of arteriotomy, whereby blood is withdrawn from the patient preoperatively via the arterial route and then replaced, in part or *in toto*, by the same manner at the end of operation. Such preoperative reduction of the total circulating volume of blood by the removal of 500 to 2,000 cubic centimeters of blood serves to lower the arterial pressure to a level between 90 and 50 millimeters of mercury and at the same time produces peripheral vasoconstriction. Arteriotomy thus approximates a state of hemorrhagic shock and has been thought by some to exceed the bounds of physiologic rectitude. Two years later, in 1948, Gillies produced normovolemic hypotension by decreasing peripheral resistance with what he termed total spinal block: the blood pressure was reduced to a level of 70 millimeters of mercury or less by the use of spinal analgesia, achieving paralysis of the entire efferent sympathetic outflow but with lesser degrees of sensory and motor blockade. Gillies has admitted the "physio-

logic trespass" of even this technique, but he has assumed that the arteriolar dilatation so produced guarantees normal oxygenation of the tissue cells, and that the decreased cardiac output inherent in the technique is compensated for by the decreased peripheral resistance and, therefore, the decreased work of the heart. The introduction of the easily injectable ganglionic blocking agents in the form of the methonium compounds led to the widespread usage of hexamethonium and pentamethonium to lower the blood pressure by decreasing the peripheral resistance. More recently, arfonad, a thiophanium compound, and to a lesser extent, pendiomide, a diethylenetriamine derivative have made possible more readily controllable ganglionic blockade for this purpose.

The effects of an intentional decrease in blood pressure upon certain vital organs are of paramount importance, particularly as they influence basic functions of the heart, brain, liver, and kidneys. It has been a source of considerable amazement that, except when radical postures have been employed, physiologic measurements during hypotension induced by a decrease in peripheral resistance have failed to reveal the extent of physiologic derangement that might have been expected. During maintenance of hypotensive states by artificial vasodilatation, there is a decreased cardiac output and a diminished stroke volume; these are compensated for in part by an accompanying decrease in the oxygen consumption of the heart and a decrease in the calculated work of the left ventricle. Coronary blood flow is decreased in direct relation to the fall in arterial pressure but the coefficient of myocardial oxygen extraction is not increased which indicates that there is adequate oxygen to support myocardial function relative to the work demanded of it despite the reduced coronary flow. The brain fares poorly when the surgical posture is such that the head is raised to any appreciable extent above the heart; in the supine position, however, a decrease of cerebral vascular resistance, and a more complete extraction of oxygen from the blood flowing through the brain, serve as compensatory mechanisms to maintain cerebral metabolism near normal during induced hypotension, at least until the cerebral blood flow is decreased to a critical rate of 30 cubic centimeters per minute per 100 grams of brain tissue. The flow of blood in the hepatic artery is decreased during hypotension, but studies of liver function usually have shown only transient hepatic malfunction following the use of the hypotensive techniques. Urine formation is regularly suppressed if the level of blood pressure is reduced below that necessary for glomerular filtration; however, despite the production of some albuminuria, renal function generally returns to normal upon the restoration of normotension.

Nevertheless, the occurrence of nonfatal and fatal complications following the use of these techniques has been extremely common. The complications encountered in 27,930 cases reported in a recent survey totaled 908, representing the amazingly high rate of 1 in every 31 cases. Suppression of kidney function, in the form of anuria or oliguria, occurred 106 times. Thromboses of various essential arterial supplies, including cerebral, retinal, and coronary, were reported in 50 cases and frequently were associated with a mortality. Cardiac arrest or cardiovascular collapse occurred on 58 occasions and, again, frequently were followed by death. Reactionary hemorrhage was the most common important complication, occurring 243 times. Prolonged effects, either persistent hypotension or delayed awakening, were reported in 269 cases. Blurred vision was found postoperatively in 127 patients due to the cycloplegic action of the ganglionic blocking agents, while miscellaneous complications were encountered in another 45 cases. There were 96 fatalities associated with the use of these techniques in the 27,930 cases reported in the survey or a mortality rate of 1 in 291 patients. Compromise of the circulation to such vital structures as the kidney, brain, and heart ac-

counted for more than 50 per cent of these deaths. Reactionary hemorrhage caused a further 8 deaths, while the techniques themselves were at fault in 5 deaths that followed high spinal analgesia and in 1 instance of overheparinization during arteriotomy. Arterial air embolism, aortic-femoral thrombosis, pulmonary infarcts and edema, and persistent hypotension accounted for all the other deaths that might be attributable directly to the induced hypotension.

The explanation of this paradox between the results of the physiologic studies upon the effects of the hypotensive techniques and the occurrence of these considerable numbers of fatal and nonfatal complications has been thought by Pask to reside in the principle of the critical closing pressure of small blood vessels. The flow of blood through small vessels cannot be considered as though the latter were simply tubes, with a linear relationship between flow and pressure and a cessation of flow when the pressure is zero; rather, the relationship must be considered nonlinear, with flow ceasing at a critical closing pressure despite the presence of a standing head of pressure. Such an explanation, based upon the facts that small vessels are distensible and that there is an anomalous viscosity of the blood flowing within them inasmuch as the corpuscles stream axially down the center of the vessels, has considerable merit. The incidence of complications following induced hypotension has been shown statistically to be significantly higher when the blood pressure is reduced to 80 millimeters of mercury or below than if the arterial pressure is permitted to remain above that level.

The particular dangers of induced hypotension in the presence of certain pathologic entities are readily understandable on this basis. Cardiovascular disease in general, including coronary disease, arteriosclerosis, cerebrovascular disease, and severe hypertension; hepatic disease; renal disease; and marked disturbances of blood volume, specifically anemia, hemorrhage, shock, low blood volume, and polycythemia, are all considered to be contraindications to the use of the hypotensive techniques. It must be realized, however, that these are dangerous techniques employed only on the basis of calculated risk: if the indication for their use is rational and urgent enough, a list of contraindications should have little real meaning except as a single factor in the equation of decision.

The indications for the use of induced hypotension defy precise definition: certainly they have shrunk in number since the original wave of enthusiasm for these techniques. In clinical practice today, they most frequently include the control of gross hemorrhage during the operative treatment of extremely vascular brain tumors or intracranial aneurysms (although hypothermia is largely superseding hypotension in the latter instances); the control of excessive vascular ooze during extensive dissections such as radical abdominal or pelvic eviscerations; the production of a bloodless operative field when a single drop of blood may obscure visibility and negate the entire surgical effort, as in the critical stage of the Lempert fenestration operation; the reduction of intravascular tension to permit the safer handling of bulging vessels in certain instances of cardiac and great vessel surgery; and the control of hypertensive crises during adrenalectomy. In view of the alarming incidence of morbidity and mortality associated with these techniques, the fundamental indication in all instances must remain the probable failure either of the patient to survive the operation or of the surgical procedure to be completed successfully were hypotension not induced.

THE NURSING PROBLEM

WILLIAM F. MACFEE, M.D., F.A.C.S., New York, New York

THE CURRENT SHORTAGE of trained nurses is a matter of concern to all who have responsibility for the care of patients. A number of hospitals have been obliged to close patient areas because of the lack of nurses, and in some localities it has become almost impossible to provide adequate nursing care even for patients who are seriously ill. A few nurses are willing to accept individual patient care but for the most part they are graduates of 15 or more years ago, and their number is diminishing. The graduate of today occasionally will do group nursing in the ward or private pavilion of a hospital but often this is only a means of obtaining funds to prepare for work in some other field.

The reasons for the nursing shortage are varied. Many hospitals have found themselves financially unable to maintain schools of nursing. Training school curricula have greatly reduced the time a student nurse spends in practical training in the wards, and the hospital derives relatively little benefit from its training program. Hospitals are also discouraged by the fact that out of large graduating classes few remain to serve the parent institution.

Business and industry have had a two-fold influence in reducing the number of trained nurses available for patient care. In the first place, they have opened new fields of employment for women, particularly since the beginning of World War II, with the result that fewer women are interested in professions like nursing and teaching. Furthermore, business and industry have found it advantageous to maintain infirmaries for their employees and have engaged the services of many graduate nurses to work in these clinics. Salaries, working hours, and pension plans as well have been made attractive.

It is probable that the disinclination of nurses to engage in the actual care of patients is to some extent a reflection of their teaching. In recent years emphasis has been placed upon training nurses for supervisory and administrative duties with relatively little stress on the practical aspects of the profession. As a matter of fact, bedside nursing has been actively discouraged.

An early definitive solution of the nursing problem is not easy to visualize, but some progress has been made. A limited amelioration has been effected by comparatively recent changes in the active treatment and convalescent care of patients. The antibiotics, for example, have diminished the nursing requirements in many infectious diseases by shortening the period of disability, and early ambulation, introduced primarily to lessen the dangers of thrombosis and embolism, has had an important side effect in reducing the need of prolonged nursing attention. Further economies of nursing personnel appear possible through the greater development of group plans of nursing, but apparently there are insurmountable obstacles to the creation and successful operation of co-operative arrangements of this kind. Savings in nursing time and energy undoubtedly could be effected also by greater employment of labor-saving devices. In this age of engineering wonders it is remarkable that primitive methods still prevail in meeting the bodily needs of patients. Drinking water, for example, is still brought to each patient in an individual container; oxygen may be piped to the patient's bedside from a central storage point, but water is still distributed in the traditional time-consuming manner.

The plan of economy which appears to be most favored by nursing supervisors is the delegation of nursing duties to less skilled

assistants, known as hospital aides, nurse assistants, or practical nurses. The work of these assistants would be supervised by graduate nurses, preferably with college degrees. It is not clear where or how nursing aides are to be trained; this responsibility has not been assumed by the organized nursing profession. It is obvious, however, that if practical nurses are to be charged with the duties of graduate nurses, their training and intelligence must be commensurate with their responsibilities. There are undoubtedly many situations in which a nursing aide can adequately perform services which formerly were considered duties of the nurse, but drawing the line between what an aide may and may not safely do calls for great sagacity.

Unfortunately, the present trend among nursing supervisors is to delegate more and greater responsibilities to nursing assistants whose ability to perform such duties may be questioned. For example, surgeons who are held morally and legally responsible for everything that happens to their patients in or out of the operating room are being asked to accept aides as substitutes for instrument nurses in the operating room. In the mind of the surgeon, at least, the operating room is one of the most critical areas in the hospital. If graduate nurses are not needed there, it hardly seems necessary to have them anywhere. The trend in training schools, however, is toward reduction of the time a student nurse spends in the operating room and some are inclined to omit operating room training altogether.

The merits of the educational policies which are now being pursued in schools of nursing must be finally appraised at the bedside. Unfortunately, it cannot be claimed that they have led to the better care of patients. Whatever the causal relationships may be, the quality as well as the availability of nursing service has deteriorated. Exceptions to this general observation are found in the older group of nurses and individually among recent graduates.

With the results of the present teaching code before them, the leaders in the nursing profession should stop and take bearings. Movement in the wrong direction is not progress. Prior to the advent of the practical nurse and supervisor concept, schools of nursing with 3 year courses of training and reasonable entrance requirements produced many fine nurses. Head nurses came up from the ranks and knew all phases of their work. Advancement to supervisory positions was open to anyone who had the ability and was willing to take the necessary additional training.

It is evident to everyone that a solution of the nursing problem is urgent, and when a public need becomes sufficiently pressing a solution of some kind is found. In this case let us hope it will be found by the nursing profession. The patient and his doctor are vitally interested parties and any satisfactory settlement must meet their needs. The answer to this problem does not lie in the substitution of relatively untrained nurse assistants to perform the duties of graduate nurses.

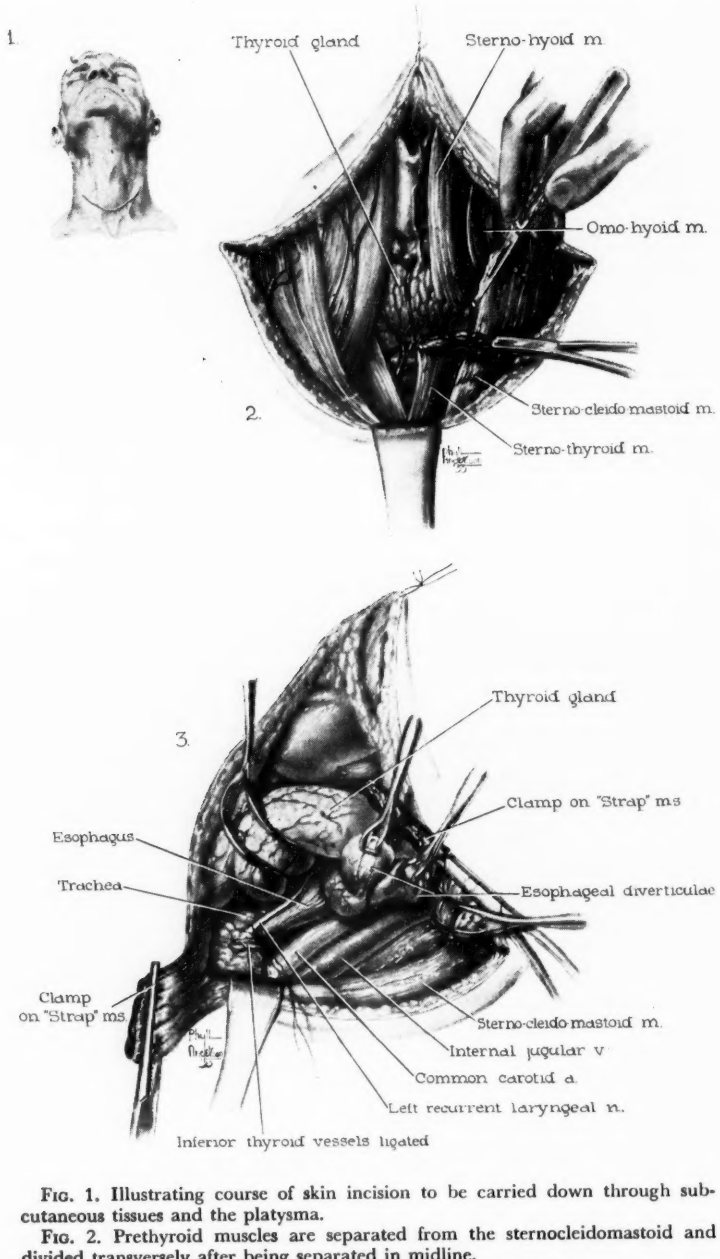


Fig. 1. Illustrating course of skin incision to be carried down through subcutaneous tissues and the platysma.

Fig. 2. Prethyroid muscles are separated from the sternocleidomastoid and divided transversely after being separated in midline.

Fig. 3. Pharyngoesophageal diverticuli exposed and mobilized after anterior and medial retraction of left lobe of thyroid. Sternocleidomastoid muscle retracted laterally exposing carotid sheath. Diverticular sacs were dissected from superior mediastinum.

A Thyroidectomy Type (Transverse) Incision for Excision of Pharyngoesophageal Diverticula—Robert T. Gants and Arthur Cohen.

THE SURGEON AT WORK

A THYROIDECTOMY TYPE (TRANSVERSE) INCISION FOR EXCISION OF PHARYNGOESOPHAGEAL DIVERTICULA

ROBERT T. GANTS, M.D., F.A.C.S., and ARTHUR COHEN, M.D.,

Medical Corps, United States Army

DIVERTICULA OF THE CERVICAL ESOPHAGUS, or those occurring at the posterior aspect of the pharyngoesophageal junction and sometimes known as a pulsion or Zenker's diverticulum, have been treated successfully by surgical excision since 1884. Surgical techniques for treating this condition have developed as a result of the advances made in diagnosis, the understanding of surgical anatomy, anesthetic techniques, surgical physiology, and in the prevention and control of infection. The two stage method of surgical treatment, as advocated by Lahey (2–4, 7–9), is gradually being replaced by the single stage method of excision of the sac and repair of the defect at the junction of the pharynx and esophagus.

Various operative incisions for exposure and excision have been employed. The one most commonly used is vertical or longitudinal and parallels the anterior border of the sternocleidomastoid muscle. This type was advocated by Lahey, who maintained that adequate exposure of the lesion and vital anatomic structures was better accomplished through this approach. He considered the importance of the cosmetic result of a transverse or oblique incision following a natural skin fold to be secondary to satisfactory exposure. His two stage method of surgical treatment was better facilitated by the longitudinal incision.

Several types of transverse incisions have been advocated by various surgeons. Crile and Dinsmore advocated a thyroidectomy-like incision but did not describe exposure technique of the diverticulum. All of the incisions, except theirs, were limited to one side of the neck, and usually followed a natural skin crease. Improved cosmetic results were responsible for these types of incisions. Other surgeons have described oblique incisions along the posterior border of the sternocleidomastoid muscle. Pauchet recommended an L-shaped incision with the vertical portion paralleling the posterior border of the sternocleidomastoid muscle and the bottom of the L extending transversely just above the scapula where it severed both heads of the same muscle.

It is not difficult to understand why limited and modified transverse or posteriorly placed longitudinal incisions hampered exposure, hindered technical removal of the sac and closure of the defect, and endangered such unseen vital structures as vascular channels and nerves.

The incision and method of approach about to be described for removing pharyngoesophageal diverticula obviates the criticism of inadequate exposure and a poor cosmetic result.

We developed our type of incision and technique of approach after performing thyroidectomies following the method used by Lahey (5, 6) who stressed the importance of goiter incisions being made "free hand and judged by the eye" after a preliminary marking of the skin according to the patient's individual anatomic features. In following this technique for thyroidectomy, it was noted how well the trachea, esophagus, and other cervical structures from the cricoid to the

From the Department of Surgery, Walter Reed Army Hospital, Washington D. C.

mediastinum were exposed. Lahey insisted that the incision, to be good, should have two features: (1) "It should be at a level where a string of beads placed about the neck will naturally rest at the junction of the neck with the chest. (2) It should have a gentle curve." He condemned straight, unbalanced, or horseshoe incisions.

This same type of thyroidectomy incision is recommended for exposure of pharyngoesophageal diverticula. It should extend from the middle or posterior border of one sternocleidomastoid muscle to the other. The skin, subcutaneous fat, and platysma should be elevated as one layer, superiorly and inferiorly. Next, the prethyroid muscles (sternohyoid, omohyoid, sternothyroid, and thyrohyoid) should be separated from the sternocleidomastoid muscle in superior and inferior directions on whichever side the diverticular pouch is to be exposed, usually the left. The muscles should be separated in the midline and elevated from the thyroid capsule, then divided transversely at a higher level than that of the skin incision (Figs. 1 and 2). These muscle flaps are reflected superiorly and inferiorly. Gentle traction on the thyroid gland and retraction of the sternocleidomastoid muscle exposes the carotid sheath and vessels to the gland. The superior, middle, and inferior thyroid veins are divided and ligated. It is necessary to divide and ligate the inferior thyroid artery and possibly the thyroidea ima vessels. At this stage the recurrent laryngeal nerve must be identified and protected. Lateral traction on the sternocleidomastoid muscle and the carotid sheath, combined with elevation and medial retraction of the thyroid gland, gives an excellent exposure of the trachea, esophagus, prevertebral fascia, and recurrent laryngeal nerve. The prevertebral fascial layers can be separated easily and freed superiorly so that the pharyngoesophageal junction is exposed. Inferiorly, the dissection can be carried into the mediastinum with the same ease. The esophagus is easily rotated at the point where it is attached to the pharynx, thus facilitating dissection and removal of the diverticulum or diverticula (Fig. 3).

Removal of the diverticulum and closure of the esophagus can then be performed by any acceptable method. The two-layer circumcision excision and closure method described by Sweet is preferred. Interrupted No. 0000 silk sutures are used to close the defect which is also buttressed with layers of prevertebral fascia. Excision of the diverticulum and closure of the esophagus is facilitated by inserting an esophagoscope through the mouth. This helps to visualize the neck of the sac by transillumination and prevents "tenting up" of the esophageal wall which might result in a narrowing of the lumen if too much tension is applied to the diverticular sac during excision and closure. The wound is closed by approximating separate muscle layers and the skin with interrupted sutures of No. 0000 silk. Drains are not used routinely. The skin sutures are removed at the end of 72 or 96 hours.

SUMMARY

A method of approach and the use of a thyroidectomy type incision for the removal of a pharyngoesophageal diverticulum has been presented. This type of incision has the advantage of leaving a more cosmetically acceptable scar as well as allowing excellent exposure of the lesion and vital cervical anatomy. It facilitates the technique of dissection and excision of the diverticulum and meticulous closure of the defect at the pharyngoesophageal junction. The diverticulum can also be approached from either side without preoperative commitment to a single right or left incision.

REFERENCES

1. Crile, G. W., and Dinsmore, R. Diverticula of esophagus. Surg. Clin. N. America, 1924, 4: 863–869.
2. Lahey, F. H. Esophageal diverticula. Surg. Clin. N. America, 1933, 13: 525–540.
3. Idem. Esophageal diverticulum. J. Am. M. Ass., 1933, 101: 994–997.
4. Idem. Esophageal diverticula. Surg. Clin. N. America, 1941, 21: 631–639.
5. Idem. Technic of subtotal thyroidectomy. Surg. Clin. N. America, 1949, 29: 641–658.
6. Idem. Technic of subtotal thyroidectomy. In: Surgical Practice of the Lahey Clinic. Pp. 27–42. Philadelphia: W. B. Saunders Co., 1951.
7. Idem. Esophageal diverticula and the technic of their removal. In: Surgical Practice of the Lahey Clinic. Pp. 175–195. Philadelphia: W. B. Saunders Co., 1951.
8. Idem. Esophageal diverticula. Surg. Clin. N. America, 1953, 33: 813–826.
9. Lahey, F. H., and Warren, Kenneth W. Esophageal diverticula. Surg., Gyn. Obst., 1954, 98: 1–28.
10. Pauchet, V. Diverticules de l'oesophage. Technique Chir., 1934, 26: 161–196.
11. Sweet, R. H. Pulsion diverticulum of the pharyngeoesophageal junction; technic of the one-stage operation; preliminary report. Ann. Surg., 1947, 125: 41–48.

SIMPLE DEVICE TO CONTROL CORROSIVE EXCRETIONS FROM UPPER DIGESTIVE TRACT FISTULAS

F. A. DEPEYSTER, M.D., F.A.C.S., Chicago, Illinois

THE MANAGEMENT of a corrosive excreting upper digestive tract fistula, surrounded by varying areas of skin erosion, offers a major challenge to surgical care. Such a fistula usually results from leakage caused by gunshot wounds and occasionally from surgery of the pancreas or upper intestinal tract.

The *sine qua non* of local care is to prevent digestive juices from contacting the skin. The absence of a protruding mucosal cuff, together with surrounding skin erosion precludes the successful use of bags employing the Koenig-Rutzen principle or appliances of more recent design, as described by Fox and Brush and by Turnbull. Application of absorbent compounds, fullers' earth, peptone solutions, or urea compounds do not provide satisfactory skin protection. Neither has the use of protective agents, such as zinc oxide, aluminum compounds, vinylite resin, or karaya powder, proved entirely satisfactory. Frequent dressing changes or dependent drainage by use of a Bradford frame, though effective, are equally trying to the patient and nurses. Metallic suction appliances designed for ileostomy control, for instance, those described by Levy, Lium, and Walker-Brash, may be used but are objectionable because of their relative unavailability, high cost of manufacture, inadaptability to various tract diameters or skin contours, and tendency to produce pressure necrosis. Intraluminal inflatable bag catheters, as described by Strelinger, are also unsatisfactory because they tend to be extruded from the tract and they encourage pressure erosion.

A simple device is illustrated (Figs. 1 and 2) which controls constant corrosive excretions from upper digestive tract fistulas. The basic elements are a multiperforated catheter which is

From the Department of Surgery, Presbyterian Hospital, Chicago, affiliated with the University of Illinois.

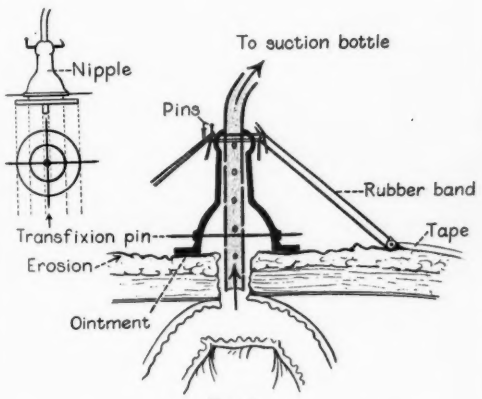


FIG. 1.

FIG. 1. Cross section drawing showing the appliance in place. Note that the nipple base is placed directly on the ointment covered eroded surface with the tip of the catheter extending into the tract. Suction applied to the catheter creates a partial vacuum within the nipple, holding the appliance in place. Elastic bands provide additional support. Inset shows detail of transfixion pins centering catheter in nipple.

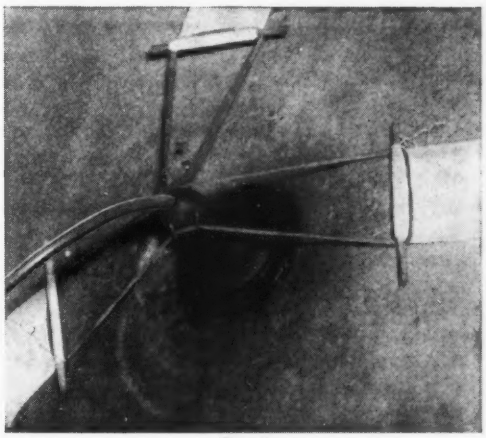


FIG. 2.

FIG. 2. Device being used to control a jejunal fistula. The supporting rubber bands provide stability when the patient is sitting up or when the patient is turned on his side.

passed through an evenflow® rubber nipple and stabilized by transfixion pins. The device is placed over the fistula with the tip of the catheter into the tract. Vitamin A and D ointment, previously applied to the eroded skin about the fistula, forms an airtight union between the nipple and skin. Moderate suction holds the nipple in place, anchored by the tip of the catheter in the tract and supported by elastic bands.

Advantages of this appliance are: The skin is protected from digestive juices by a device which can be applied directly to the eroded area; no other dressings are required, and thus nursing care is reduced; construction is simple, made from inexpensive materials, readily available and easy to clean; the patient need not be confined to bed; the soft rubber nipple base conforms to irregular skin contours and, with moderate suction, will not cause pressure necrosis; the catheter may be changed to fit tracts of varying diameters; epithelization of the erosion proceeds under the nipple base to the catheter where a "collar" of granulation tissue forms, ultimately closing or providing satisfactory conditions for skin adherent ileostomy appliances.

REFERENCES

1. Fox, J. DeWitt, and Brush, Brock E. A new ileostomy-colostomy device with a disposable plastic bag and no cement. J. Am. M. Ass., 1954, 156: 1398–1399.
2. Levy, Samuel. An aid in the postoperative management of temporary ileal fistula after the Lahey right hemicolectomy. Brit. J. Surg., 1945–1946, 33: 160–162.
3. Lium, Rolf. A suction tube for ileostomy. N. England J. M., 1937, 216: 8.
4. Strelinger, Alexander. An appliance for preventing leakage of gastrostomy and enterostomy. Am. J. Digest. Dis., 1948, 15: 14–16.
5. Turnbull, Rupert B., Jr. Management of the ileostomy. Am. J. Surg., 1953, 86: 617–624.
6. Walker-Brash, R. M. T. An apparatus for drainage of a temporary ileostomy. Brit. M. J., 1947, 2: 572.

EXPLORATION OF THE PANCREATIC DUCT FOR PANCREATITIS

MARSHALL K. BARTLETT, M.D., F.A.C.S., and WILLIAM V. McDERMOTT, JR., M.D.,

Boston, Massachusetts

THERE HAVE BEEN MANY STUDIES concerned with the etiology and pathogenesis of pancreatitis in its varying clinical and pathologic forms. This report is not an attempt either to review the literature concerned with pancreatitis or to present evidence favoring any particular factors concerned with its etiology or pathogenesis. The evidence available does suggest, however, that the development of pancreatitis in either its acute or recurrent form is frequently dependent upon obstruction to pancreatic outflow from an actively secreting gland.

The problem of the patient who has had one or more attacks of pancreatitis remains a difficult one, and it seems certain that no one procedure now available will prove to be successful in the treatment of all such cases. Nonetheless, one can adopt a rational approach to this disease, and we believe that the initial surgical attack should consist of a thorough exploration of the biliary tree, correction of any pathologic process demonstrated there, and exploration of the opening of the main pancreatic duct into the duodenum. If stenosis of this opening is found, every effort should be made to correct it. Exploration of the pancreatic duct has also been advocated by others including Starr, Warren, and Walters.

Successful identification and exploration of the main pancreatic duct requires an intimate knowledge of the anatomy. Many excellent studies have contributed to a better understanding of the anatomy of the pancreatic ducts and their relationships to the common bile duct and the papilla of Vater including those of Simkins, Rienhoff and Pickrell, Howard and Jones, Millbourn, and Kleitsch.

The duct of Wirsung either joins the common bile duct before the latter enters the duodenum (95 per cent) or itself enters the duodenum separately at the papilla of Vater adjacent to the opening of the common bile duct (5 per cent). The duct of Wirsung is the main excretory duct of the pancreas in about 90 per cent of cases, with a patent communication with the duct of Santorini and the duodenum at the lesser papilla in 40 to 60 per cent.

In 10 per cent of cases the duct of Santorini is the main excretory duct, entering the duodenum through the lesser papilla, always anterior and proximal to the papilla of Vater. This distance may vary from 0.9 to 3.5 centimeters, averaging 2.0 centimeters. Under these circumstances there is usually no patent anastomosis with the duct of Wirsung. These anatomic variations are shown in Figure 1.

In carrying out the operation we proceed as follows:

1. If the gallbladder has not been removed previously, the cystic artery and duct are exposed and loops of suture material are placed around them but not tied. These serve the purpose of identification and retraction, and in the case of the latter of preventing the escape of stones into the common bile duct. We prefer to postpone removal of the gallbladder to the end of the procedure in case some situation is found which might make the presence of the gallbladder desirable for anastomosis to the gastrointestinal tract. The duodenum and head of the pancreas are mobilized after dividing the lateral peritoneal attachments of the duodenum and freeing the hepatic flexure of the colon.

2. The common duct is opened and explored to assure the removal of whatever stones may be present. The position of the papilla of Vater is then determined and its lumen calibrated gently by means of graduated Bakes dilators.

3. The duodenum is opened longitudinally on its anterior or anterolateral surface, for a distance of about 4 centimeters, centered over the papilla of Vater.

4. The margins of the duodenotomy are retracted and the papilla of Vater inspected. This

From the Department of Surgery, Harvard Medical School, and the Surgical Services, Massachusetts General Hospital, Boston.

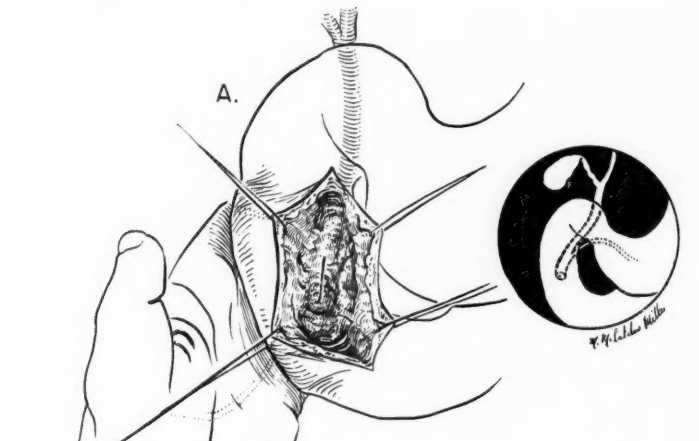


FIG. 1. A, The duodenum has been opened and the papilla of Vater exposed. The line of incision for sphincterotomy is shown. The insert shows the usual arrangement of the duct of Wirsung and the common bile duct. B, The margins of the incised common bile duct are retracted to expose the opening of the duct of Wirsung. C, The mucosa of the duodenum has been approximated to the common duct wall to facilitate healing, and the septum between the duct of Wirsung and the common bile duct has been incised to enlarge the opening of the pancreatic duct. D, Alternate, less usual relationships of the pancreatic and common bile ducts are shown. On the left, the duct of Wirsung enters the duodenum at the papilla of Vater adjacent to the opening of the common bile duct. On the right, the duct of Santorini is the main pancreatic duct entering the duodenum at the lesser papilla, anterior and proximal to the papilla of Vater. A small duct of Wirsung drains a small portion of the pancreas and joins the common bile duct in the usual manner. E, A plastic procedure has been done to enlarge the opening of the duct of Santorini with approximation of the cut margins of the duct wall to the duodenal mucosa with fine interrupted sutures. The upper margin of the papilla of Vater is seen at the lower left.

will usually show the duct of Wirsung entering the duodenum at the papilla of Vater adjacent to the opening of the common bile duct or the frequent, intermittent emission of small amounts of clear pancreatic fluid from the bile duct opening will give a clue to the entrance of the duct of Wirsung into the common bile duct at a higher level.

5. A sphincterotomy is then performed, dividing the posterior duodenal wall and the anterior wall of the common duct proximally for 1.5 centimeters from the papilla of Vater (Fig. 1A). Traction sutures are placed on the divided margins of the papilla to expose the floor of the bile duct, and the area is inspected for the opening of the duct of Wirsung. The cut edges of the common duct wall are approximated to the overlying duodenal mucosa with interrupted sutures of No. 5-0 chromic catgut. This procedure serves the dual purpose of providing hemostasis and preventing stenosis by reducing the amount of scar tissue in the healing process.

6. If no opening of the duct of Wirsung is found in the exposed floor of the common bile duct a search must be made for the opening of the duct of Santorini at the lesser papilla. This is a small structure, hard to locate, and a flow of pancreatic juice may be the only clue to its position. Secretin stimulation of the pancreas may be useful.

7. When the opening of the pancreatic duct has been identified, either at the papilla of Vater, in the common duct, or in the duodenal mucosa, its diameter is gently calibrated and explored for a sufficient distance to make sure that it is the main excretory duct. This procedure must be performed with care as any undue trauma may cause a flare-up of pancreatitis. A normal duct will usually admit a 3 millimeter dilator with ease, but at times the opening of the duct may be very stenosed and in that event fine lacrimal duct probes are useful in exploring such tiny orifices. The pancreatic duct proximal to a stenosed opening into the common duct or duodenum may be 0.5 centimeter or more in diameter and an adequate orifice can be easily created. The duct is incised in its long axis together with the overlying common duct wall or duodenal mucosa for a distance of approximately 0.5 centimeter. In the case of a separate entrance into the duodenum the thin wall of the pancreatic duct is carefully approximated to the duodenal mucosa by several interrupted sutures of No. 5-0 chromic catgut (Fig. 1E).

8. If desired, the pancreatic duct system can be outlined on roentgenograms by using a fine catheter and suitable contrast medium.

9. The duodenotomy is closed with 2 layers of fine running catgut and an outer layer of interrupted cotton, care being used to turn in a minimum of duodenal wall to prevent undue narrowing of the lumen.

10. The choledochostomy is closed around a suitable T tube. If the gallbladder is present it is removed after ligation of the cystic artery and the cystic duct 0.5 centimeter from its entrance into the common duct. A cigarette wick is put down to Morrison's pouch and brought out with the T tube through a small muscle-splitting incision in the right flank separate from the laparotomy incision, which is then closed in the usual manner.

SUMMARY

If surgical exploration of the biliary tree is undertaken in cases of recurrent pancreatitis, exploration of the main pancreatic duct and the establishment of an unobstructed pancreatic outflow should be an integral part of the operation. A technique for accomplishing these objectives is described.

REFERENCES

1. HOWARD, J. M., and JONES, R., JR. Anatomy of the pancreatic ducts; the etiology of acute pancreatitis. Am. J. M. Sc., 1947, 214: 617–622.
2. KLEITSCH, W. P. Anatomy of the pancreas. Arch. Surg., 1955, 71: 785–802.
3. MILLBOURN, E. On the excretory ducts of the pancreas in man; with special reference to their relations to each other, to the common bile duct, and to the duodenum. Acta anat., Basel, 1950, 9: 1–34.
4. RIENHOFF, W. F., JR., and PICKRELL, K. L. Pancreatitis; anatomic study of the pancreatic and extrahepatic biliary systems. Arch. Surg., 1945, 51: 205–219.
5. SIMKINS, W. Variations in the pancreatic ducts and the minor duodenal papilla. Am. J. M. Sc., 1931, 192: 626–639.
6. STARR, K. W. Obstructive and pancreatic problems following choledochostomy. Arch. Surg., 1953, 66: 398–399.
7. WALTERS, W. Postcholecystectomy dyskinesia with pancreatitis, sphincteritis and choledocholithiasis as causes. J. Am. M. Ass., 1956, 160: 425–431.
8. WARREN, K. W. Surgical considerations in the management of chronic relapsing pancreatitis. Surg. Clin. N. America, 1955, 35: 785–799.

THE SURGEON'S LIBRARY

Reviews of New Books

THE VOLUME entitled *New Concepts in Surgery of the Vascular System*[1] contains two lectures delivered by the author, the first being the David W. Yandell Memorial Lecture presented in 1953 at the University of Louisville School of Medicine, and the second being an Arthur Dean Bevan Lecture presented before the Chicago Surgical Society in 1954. Each lecture contains important material in the field of arterial disease and injury, gathered and presented to be of interest not only to vascular surgeons but to surgeons in general and indeed to all doctors.

The first lecture is titled "The Immediate and Late Treatment of Arterial Injuries." The author has gathered together the statistical analyses available concerning arterial reconstruction during the Korean War. This report is presented in one place in this volume and is analyzed by the author. The steps of treatment of acute arterial injuries are presented in a remarkably clear and concise manner.

The manner in which an arterial venous fistula forms in response to trauma has never been so reasonably and clearly described. The physiologic changes that accompany such a fistula and the treatment of an already established lesion of this type are described. General interest, as well as specialized interest, in vascular surgery is engaged by the clear presentation of principles plus technical details of surgical treatment which come from the author's experience.

The second lecture is titled "The Significance of Segmental Stenosis and Post-Stenotic Dilatation in the Development of Arterial Aneurysms." The results of the author's long term interest in the dynamics of blood flow and the specific problem of formation of aneurysms provide the basis for this lecture. The principle of poststenotic dilatation has been shown to obtain not only for constriction of blood vessels but also for mechanical systems through which blood is pumped, the flow being disturbed by constriction. The presence of turbulent and reversed flow beyond a point of stenosis clearly becomes the cause of poststenotic dilatation. A group of very interesting clinical examples of poststenotic dilatation thoroughly covers the manner in which this principle is of practical importance. The subtitle of this lecture is "The Biologic Importance of Structural Fatigue." The concept that human tissues are subject to the same response to continued stress is new in this field of medicine. The author presents this idea not only as it pertains to the blood vessels but also to bone and other tissues.

The volume is interesting as delightful reading to one not previously informed or particularly interested in this field; while to one whose interest lies principally in the direction of vascular problems, it represents a concise, beautifully written collection pertaining to the subject of each lecture. —*Ormand C. Julian.*

IN THE REVIEWER'S OPINION, the author of *Complications of Regional Anesthesia*[2] presents a good coverage of a subject which should be familiar to anyone using local anesthetic agents. All aspects of possible complications are reviewed and when controversial topics evolve, he is quite honest in presenting both sides and follows up with his ideas and the reasons for them. Repetition occurs, but this is difficult to avoid in presenting a comprehensive discussion. It should be added, however, that statements repeated are those of utmost importance, and the repetition probably helps to imprint them on the reader's mind.

The book is published in easily read print, and the language used is easily understood by anyone having a medical background. Illustrations, photographs, and factual tables are used freely, and add much to the understanding of the topic in question. The author encloses long reference lists which, for the interested reader, supply a wealth of additional information.

Topics are so arranged that one can become familiar with the book in a brief period of time and after this, the book would serve as an excellent reference with rapidly accessible information.

A goodly portion of the book refers to spinal analgesia and its complications, but the subject of complications due to the local anesthetic agents administered by any technique is well covered. I highly recommend this treatise to anyone dealing with the local anesthetic agents. It presents a comprehensive coverage of a subject which should be common knowledge to these persons. —*Donald E. Howland.*

THE SECOND BOOK on urinary incontinence, *L'incontinenza urinaria nell'uomo e nella donna e suo trattamento*[3] to

[1] NEW CONCEPTS IN SURGERY OF THE VASCULAR SYSTEM. By Emile Holman, M.D. 108 pages, 47 illustrations. $3.50. Springfield, Ill.: Charles C Thomas, 1955.

[2] COMPLICATIONS OF REGIONAL ANESTHESIA, ETIOLOGY-SIGNS AND SYMPTOMS-TREATMENT. By Daniel C. Moore, M.D. 291 pages, 51 illustrations. $10.50. Springfield, Ill.: Charles C Thomas, 1955.

[3] L'INCONTINENZA URINARIA NELL'UOMO E NELLA DONNA E SUO TRATTAMENTO. By Bruno Geremia and Antonio Tormene. With a preface by Prof. G. Ceccarelli. 278 pages, 70 illustrations. Bologna: Cappelli Editore, 1955.

appear during the past 3 years points up the importance of this clinical problem which is as yet incompletely solved. The book is very well organized and profusely illustrated. The bibliography is extensive and up to date. It includes not only the pertinent American and English literature on this subject but also many French, German, Italian, and Spanish papers frequently omitted from our literature.

The embryology, anatomy, and physiology of the bladder and urethra are well reviewed, and the many causes of urinary incontinence are thoroughly discussed with particular attention given to the most common type of all, namely, urinary stress incontinence in women.

There is a brief chapter on incontinence in the male. Some of the operations listed for its relief, while culled from the recent British and American literature, are questionable from a pathologic-physiologic point of view and are far from accepted in this country or abroad. To see these operations described in a book may give the less critical reader the impression that they are well established procedures, when actually the reverse is true.

The operative management of urinary stress incontinence in women, on the other hand, is much more critically considered. All the current operations are well described, and many of the illustrations are taken from original sources. It is interesting to note that the authors favor the Perrin-Leger procedure rather than the Aldridge, Millin-Read, or Marshall-Marchetti operations which are more commonly used in this country.

Included in the last chapter of the book are tables which list the experience of many authors with the 3 essential types of operations designed to cure urinary stress incontinence. These tables list the number of cases reported by each author, together with the percentage of his successes and failures. They constitute a useful digest of the extensive literature on the operative correction of stress incontinence.

This monograph is a worthwhile addition to the literature on urinary incontinence and should be of particular value to surgeons on the continent or in the South American countries who read Italian more easily than English. —*S. Richard Muellner.*

THE VOLUME entitled *Surgery in World War II; Vascular Surgery*[4] is a very interestingly written history of vascular injuries edited by Daniel C. Elkin and Michael E. DeBakey. They and others assigned to vascular centers in this country during World War II recorded their clinical experiences, clinical investigations, diagnostic procedures, methods of treatment, and results.

Vascular Surgery "does purport to give a reasonably complete accounting of complications which followed combat-incurred vascular injuries in casualties evacuated to the Zone of Interior. It also includes an account of peripheral vascular disorders observed in Army personnel during World War II, with the exception of trench foot, immersion foot and cold injuries."

The volume contains many excellent photographs, drawings, and charts. Tables recording the frequency of vascular injuries, anatomic locations, their complications and effects on the circulatory system, are clearly presented and most informative.

Basic principles in the treatment of acute and chronic vascular injuries, with the pros and cons, are well presented along with a review of the literature and an excellent bibliography. For example, the opinions of surgeons concerning ligation of the concomitant vein covered 6 pages. The conclusion of the authors was that "ligation of the concomitant vein does not, in any way, increase the chance of survival of the limb."

Nine of the 16 chapters are concerned with the problems associated with aneurysms and arteriovenous fistulas. The investigations included studies of the local and systemic effects of arteriovenous fistulas on the circulation and their effect on the size of the heart, the cardiac output, and blood volume.

The exposure and management of blood vessels and various methods of arterial repair are discussed, and one conclusion that the transverse suture of the defect in the arterial wall after excision of the damaged portion is the most satisfactory method of arterial repair.

Preoperative and postoperative care are well discussed, and case histories with illustrated results and complications are presented.

Thromboangitis obliterans, arteriosclerosis, arterial thrombosis, embolism, and vasospastic disorders, as they occurred in Army personnel are well presented as to incidence, diagnostic methods, and treatment.

Sympathectomy is evaluated for the preoperative and postoperative period and as the procedure of choice for various circulatory disturbances. Differences of opinion and the results are most interesting.

Following World War I, the surgical specialty of vascular surgery was given "just a single paragraph" in the medical history of that conflict. This volume records the advances made in the knowledge and treatment of vascular injuries between the first and second World Wars, and the important contributions made by the various authors at the Vascular Centers. This unique historical volume will be a most helpful addition to a surgeon's library. —*Egbert H. Fell.*

IT IS DIFFICULT TO REVIEW the book *Pathologic Physiology; Mechanisms of Disease*[5] in a general way for it reaches considerable heights and considerable low points. Such a text precludes making favorable or unfavorable generalities. The review is written from the point of view of the book's various parts.

Pathologic physiology, an appealing cliché in modern medicine, is largely undefined. Pathologic physiology is here defined as an analysis of symptoms and signs and the mechanism of their development. The clinical picture of disease is presented as seen as physiologic dysfunction. This is not generally accomplished. A problem here is that of "high verbosity prose." It is a very difficult, exasperating, and time-consuming job to reduce one's writing to the hard

[4]SURGERY IN WORLD WAR II; VASCULAR SURGERY. Edited by Daniel C. Elkin, M.D., and Michael E. DeBakey, M.D. 465 pages, 56 illustrations. Washington, D. C.: Office of the Surgeon General, Department of the Army, 1955.

[5]PATHOLOGIC PHYSIOLOGY; MECHANISMS OF DISEASE. Edited by William Sodeman, M.D., F.A.C.P. 2nd ed. 963 pages, 173 illustrations. $13.00. Philadelphia and London: W. B. Saunders Co., 1956.

central core of literate verbal construction; it is not accomplished in this book. One is reminded of William Makepeace Thackeray's cryptic warning "Easy writing makes damned hard reading. The only good writing is good rewriting." The impression is that this work is often "easy writing." The book is divided into 12 parts with several chapters to each part, a total of 31 chapters.

The chapter on the genetics of abnormal growth and neoplasia gives the impression that it stands in the awkward position of being unrelated to the remainder of the text. There is some useful information regarding the problem of establishing hereditary truths and recognizing false conclusions about cancer; much discourse is devoted to the relationship of fraternal and identical twins to cancer in research. How this fits into pathologic physiology is beyond the ken of this reviewer.

The section on metabolism and endocrine glands is a satisfactory review of biochemistry in carbohydrate, protein, and fat metabolism. Sentences are often long and pedestrian. There is awkward wording and confused meanings. The use of English is poor. For instance, on page 30, "When there is insufficient intake or inability to absorb properly protein, for example, in the presence of gastrointestinal barriers or severe diarrhea." Another example, "There is some evidence that such ulcers may be in part a function of the total circulating protein." How can ulcers be a function of protein? The word "disturb" is used in several connotations which seem inappropriate to the meaning of this word. On page 27 it is implied that protein contains no calories.

Water and electrolyte metabolism is presented as a separate subject. In general, this section is adequately done. There is little effort to correlate the metabolic deviations with symptoms and signs. The figures for volumes of body water are obsolete. Discussion of acidosis and alkalosis fails to bring out that the hydrogen ion is the hazard rather than anions and cations. Potassium depletion nephropathy, its biochemical and clinical reflections might have found a place here.

The dynamic interrelationships between the glands of internal secretion and their target cells is presented in excellent scientific prose. The section on infections is excellent. This extraordinary work does not always fit the aims and objectives of the book. The chapter on allergy is short, concise, and meaningful.

As usual Dr. Bean writes in clear, effective, scientific prose which is communicative and easy to read. The data on acclimatization to heat related to water, electrolyte, and hydrogen ion metabolism could have been included. This bit of pathologic physiology is lacking.

A chapter on chemical agents and disease is interesting, informative, and well written. A section titled "Changes in Low Frequency Cardiac Vibrations" seemed to stand out, as unrelated to the remainder of this chapter or the book as a whole.

The section on the circulatory system occupies about one-fourth of the book. The choice of words, length of sentences, and verbal excesses decrease the effectiveness of parts of this section. Changes in velocity and pressure within blood vessels and interpretation of arterial pulse waves are ably presented. There is close adherence to correlation of symptoms and signs and physiologic mechanisms.

The chapter on electrocardiography is excellent. Description of the electrocardiogram and the mechanism of its production is lucid, compact, and communicative. A chapter on cardiac output, hypertrophy, and dilation is well written. Diagrams are available superior to those used illustrating physiologic problems occurring in obstruction at all levels of the circulatory system. Congestive circulatory failure and cardiac function tests are well presented. The reader is left with the view that forward and backward failure remain unintegrated and that the student or practitioner may subscribe to one or the other. Presently, theories of congestive failure can be integrated into a unified and clinically usable general concept.

The section on the respiratory system is adequate. The term acid-base balance fails to show that the hydrogen ion is the central character in the act in problems of hydrogen ion control. The term fixed acid is used to describe the anion chloride; bicarbonate is referred to as a base. These terms compound existing confusion.

Chapters on the stomach, small intestine, and colon include new material and outline intestinal physiology well beyond that found in textbooks of medicine. Discussion of correlating symptoms and signs make this section very usable. New disorders are well presented in a chapter dealing with liver disease. More discussion and correlation of symptoms and signs with the physiologic deviations would have been helpful. The chapter devoted to the gallbladder and pancreas is short, mediocre, and appears to have been hurriedly done.

The kidney section, though very well done, does not seem to carry out the intent of the book. Excellent diagrams illuminate the discussion. Specific disease entities are presented in 2 pages at the end of the chapter. Potassium depletion nephropathy is not mentioned. The term base-conservation is used when hydrogen ion excretion would more effectively express the process.

The section on blood and spleen is an excellent presentation of the physiology of blood diseases, a high point in the book. It is communicative and succinct. The latter part of the chapter could well be broken up into shorter sections. It becomes tiring to read page on page without a break.

The chapter on the locomotor system is really a discussion of the physiology and biochemistry of joints. This is well done; new material is presented. The clinical section contains little that is not available in any standard textbook of medicine. The section on the nervous system, a short summary of neurology, is adequate but fails to accomplish the book's purpose as originally set forth. Very little is found correlating the bedside picture with physiologic dysfunction in disease states.

The impression gained is that a number of contributors have done their stint without adequate central integrative control and insufficient understanding of what other contributors were doing. The aims of the book do not seem to be in the minds of some of the writers. The reading itself is often hard going. Many

more words are used than necessary to communicate desired information. A need existed for a book effectively correlating the clinical picture of a disease with its physiologic dysfunction. The need still exists. In the process of editing much could have deservedly expired at the point of a blue pencil and saved the reader thick, heavy plodding. No exception is taken with the issue that the authors are very well informed. Thoughts may spring full bodied from the brows of authors but sentences and communicable chapters do not. —*John H. Bland.*

IT IS A REAL PLEASURE to review and recommend the remarkable volume entitled *Diseases of the Chest.*[6] It is produced entirely by a physician and radiologist, each outstanding in his respective field, and includes also 3 chapters written by others. The authors have included, as stated in the preface, the impressive advances made in the diagnosis and therapy of conditions which are now managed in a manner quite different from that of a decade ago. The bibliography, by intention, is quite limited. Preference has been given to medical literature of recent date which includes extensive bibliographies and provides adequate keys to previous and sometimes more important information.

The authors note that diagnosis is the cornerstone of modern medicine and requires accurate observation and rational deduction. The close collaboration of an internist and a radiologist was as important in the preparation of this book as it has proved to be in the solution of many problems involving individual patients.

Each of the 40 chapters begins with an outline of content and ends with a brief concise summary. The writing, illustrations, paper, and printing are superior in every way. A helpful index is included.

In the text, the first 4 chapters are devoted to diagnostic procedures which include: the clinical history, evaluation of complaints, physical examination, bronchoscopy, laboratory studies, and the roentgenologic examination of the thorax. Segmental anatomy is reviewed in chapter 5. Chapter 6 on measurement of pulmonary function by Roger H. L. Wilson includes a discussion of concepts of normal and pathologic physiology, tests of pulmonary function, electrocardiograms, and the study of the blood. Wilson enumerates a series of mechanisms which may affect pulmonary function and concludes that no pulmonary function study is a substitute for careful history and physical examination. The discussion of foreign bodies in the larynx and the tracheobronchial tree is presented by Walter E. Heck, who begins and ends with the admonition to think constantly of the possibility of a foreign body. He includes a discussion of the pathogenesis, pathology, clinical manifestations, roentgenology, laboratory findings, and treatment, with the observation that obviously the whole problem of aspirated foreign bodies would be resolved if small objects could be kept out of the mouth. In other chapters are given limited but adequate discussions of postoperative pulmonary atelectasis, thoracic injuries, diseases of the diaphragm, bronchial asthma, pulmonary emphysema, spontaneous pneumothorax, mediastinal disease, pulmonary congestion, edema, and embolism. In the remaining chapters various types of infection and neoplasm are considered as they involve the chest. These include the usual and unusual types. Tuberculosis receives a great deal of attention and is dealt with especially well in an unbiased manner.

This reviewer is in complete agreement with the authors' statement that they have prepared a volume which keeps pace with developments and which provides an up-to-date textbook for students and practitioners, adequately illustrated to portray most of the thoracic disorders which they are likely to encounter in practice, and sufficiently terse to permit a ready grasp of present day methods of diagnosis and treatment. —*George C. Turnbull.*

THE LAST PUBLICATION by Homer W. Smith entitled *Principles of Renal Physiology*[7] is an excellent text in which are detailed with admirable simplicity the conclusions available in this fascinating and important field at this time. Unquestionably, the dominant figure in renal physiology over the last 2 decades, Homer Smith, with his group at New York University, has provided much of the work from which such conclusions have been drawn. Thus, the physiologic dissection of the kidney, the development and standardization of the inulin clearance as a method of determination of filtration rate, the measurement of renal blood flow and tubular mass, are largely to be credited to Smith and his co-workers. With these fundamental values established, the revision of older concepts was made feasible, and a new chapter in renal physiology could be elaborated.

Prefaced by a brief section on the anatomy of the kidney, furnished with diagrammatic drawings, the author cites the historical discoveries which, through amendment or confirmation, led to the present concepts of the role of glomerulus and tubule in kidney function. This material is followed by chapters on the measurement of the rate of glomerular filtration and the prerequisites of substances suitable to such measurement, tubular reabsorption, tubular excretion, and the techniques by which the site of these activities has been determined. Upon this basic framework, the author proceeds with a discussion of substances such as urea, phosphate, sulfate, uric acid which, as plasma values or excretory products, concern the clinician. Section 9 deals with the excretion of proteins by the kidney and includes a summary of evidence tending to support each of the two currently held postulates concerning the mechanism of proteinuria.

Section 10 consists of a discussion of the fluid compartments of the body and the techniques employed for their measurement. It is followed by a section on strong electrolytes, and the factors governing their control in the kidney, which leads in turn to the subjects of diuresis, antidiuresis, hydrogen ion balance, and acid-base equilibrium, and is concluded by a

[6] DISEASES OF THE CHEST. By H. Corwin Hinshaw, M.D., Ph.D., and L. Henry Garland, M.B., B.Ch. 727 pages, 634 illustrations. $15.00. Philadelphia and London: W. B. Saunders Co., 1956.

[7] PRINCIPLES OF RENAL PHYSIOLOGY. By Homer W. Smith, A.B., Sc.D., M.S. (Hon.). 237 pages, 24 illustrations. $5.00. New York: Oxford University Press, 1956.

chapter on the formation of ammonia and the control of renal circulation.

Appended to each chapter are problems by which the reader may test his understanding of the material treated in the foregoing pages. Appended to the book are notes on the electron microscopy of the nephron and certain technical aids useful in the performance of the tests referred to in the body of the book.

Mention should be made of the rather striking number of typographic errors appearing in this book. The author explains that this regrettable fact is due to the method of printing, which resulted in so many errors as to necessitate the printing of a new edition, available in the near future.

This surprisingly brief and elegant text represents the essence of a massive volume of physiology and comparative anatomy. As its title suggests, it is a formulation of principles, and by this virtue as well as by its gratifying command of the art of writing, it is well qualified indeed to "make the art of healing more difficult and yet more certain."

—*Edith B. Farnsworth.*

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

YOU AND YOUR OPERATION. By Benjamin R. Reiter, M.D. 150 pages, 8 illustrations. $3.50. New York: The Macmillan Co., 1957.

THE OFFICIAL AMERICAN MEDICAL ASSOCIATION BOOK OF HEALTH; AN AUTHORITATIVE FAMILY GUIDE. Edited by W. W. Bauer, M.D. 320 pages, illustrated. $.35. New York: Dell Books, 1956.

A. M. A. SCIENTIFIC EXHIBITS, 1956. By American Medical Association. Sponsored by Council on Scientific Assembly American Medical Association. 411 pages, illustrated. $10.00. New York: Grune & Stratton, 1956.

THE HEAD AND NECK IN ROENTGEN DIAGNOSIS. By Eugene P. Pendergrass, M.D., J. Parsons Schaeffer, M.D., Ph.D., and Philip J. Hodes M.D. 2nd ed. Vol. I. 878 pages, 960 illustrations. Vol. II. 880 pages, 779 illustrations. $37.50. Springfield: Charles C Thomas, 1956.

A HISTORY OF UROLOGY IN EGYPT. By Professor Dr. J. Bitschai and M. Leopold Brodny, M.D. 122 pages, illustrated. Privately printed at the Riverside Press, 1956.

LESIONS OF THE CERVICAL INTERVERTEBRAL DISC. By R. Glen Spurling, M.D. 134 pages, 41 illustrations. $4.75. Springfield: Charles C Thomas, 1956.

MEMORIA DE LA VA REUNION NACIONAL DE UROLOGIA. Organizada por la sodiedad mexicana de urologia. By Sr. Adolfo Ruiz Cortines. 347 pages, illustrated. Mexico: Mayo, 1954.

PROBLEMS OF AGING. Edited by Robert L. Craig, M.D. 240 pages, illustrated. $3.50. New York: George Eliot Medical and Scientific Books, 1956.

CYTOLOGIC TECHNICS FOR OFFICE AND CLINIC. By H. E. Nieburgs, M.D. 233 pages, 171 illustrations. $7.75. New York, London: Grune & Stratton, 1956.

LIVER; STRUCTURE AND FUNCTION. By Hans Popper, M.D., Ph.D., and Fenton Schaffner, M.S., M.D. 777 pages, 204 illustrations. $20.00. New York: McGraw-Hill Book Co., Inc., 1957.

MANUAL OF ANESTHESIOLOGY FOR RESIDENTS AND MEDICAL STUDENTS. By Herman Schwartz, M.D., S. H. Ngai, M.D., and E. M. Papper, M.D. 170 pages, 13 illustrations. $4.25. Springfield, Ill.: Charles C Thomas, 1956.

LES ÉCRASEMENTS THORACIQUES. By Jean Garbay, Michel Garbay; and Claude Vanderpooten. Préface by Docteur Sauvage. 132 pages, 12 illustrations. 1.100 fr. Paris: Masson et Cie Éditeurs, 1956.

TRAITÉ DE TECHNIQUE CHIRURGICALE. By B. Fey, P. Mocquot, S. Oberlin, J. Quénu, P. Truffert, M. David, M. Iselin, R. Dossot, R. Dubau, Ch. Dubost, J.-J. Galey, Y. Longuet, J. Loygue, J. Mathey, R. Palmer, J. Perrotin, J.-C. Rudler, G. Thomeret, and J. Varangot. Vol. VIII. 2nd ed. 870 pages, 899 illustrations. Paris: Masson et Cie, Éditeurs, 1956.

Chirurgie de l'estomac. By R. Gueullette. 584 pages, 117 illustrations. 4.000 fr. Paris: Masson et Cie, Éditeurs, 1956.

HOMMAGE A RENÉ LERICHE. By Ses Élèves. Edited by P. Mallet-Guy. 494 pages, 197 illustrations. 3.000 fr. Paris: Masson et Cie, Éditeurs, 1956.

EXPOSÉS D'ANESTHÉSIOLOGIE; A L'USAGE DES PRATICIENS ET DES ÉTUDIANTS. By P. Huguenard and P. Jaquenoud. 210 pages, 30 illustrations. 1.300 fr. Paris: Masson et Cie, Éditeurs, 1956.

NEUROCHIRURGIE FONCTIONNELLE. By Pierre Wertheimer. Préface by Professor René Leriche. 186 pages, 46 illustrations. 1.500 fr. Paris: Masson et Cie, Éditeurs, 1956.

MODERN OPERATIVE SURGERY. Edited by the late G. Grey Turner, LL.D., D.Ch., M.S., F.R.C.S., F.R.C.S.E., F.R.A.C.S., F.A.C.S., and Lambert Charles Rogers, V.R.D., M.Sc., M.D., F.R.C.S., F.R.C.S.E., F.R.A.C.S., F.A.C.S. With a foreword by Sir Gordon Gordon-Taylor. 4th ed. Vol. II. 1383 pages, 613 illustrations. $17.50. New York: Paul B. Hoeber Inc., 1957.

ANAESTHETIC ACCIDENTS; THE COMPLICATIONS OF GENERAL AND REGIONAL ANAESTHESIA. By V. Keating, M.D 261 pages, 13 illustrations. $5.00. Chicago, Ill.: The Year Book Publishers, Inc., 1956.

PHYSICAL METHODS IN PLASTIC SURGERY. By Joseph P. Reidy, M.A., M.B., B.Ch.(Cantab.), F.R.C.S.(Eng.). Vol. III. 69 pages, 28 illustrations. $3.00. London: The Actinic Press, published in the U.S.A. by Essential Books, Inc., N. J., 1956.

CONGENITAL ANOMALIES OF THE VISCERA; THEIR EMBRYOLOGICAL BASIS. By J. Lewis Bremer, M.D. 202 pages, 89 illustrations. $5.00. Cambridge: Harvard University Press, 1957.

BLADDER TUMORS; A SYMPOSIUM. By Mitchell Brice, II, M.D., James L. Green, M.D., John J. Harris, Ph.D., Jack Holden, M.D., Gustavus A. Humphreys, M.D., K. T. Ma, M.D., Victor F. Marshall, M.D., J. Alan Michols, M.D., Albert J. Paquin, M.D., George R. Prout, M.D., Samuel I. Roland, M.D., and Willet F. Whitmore, Jr., M.D. 92 pages, 8 illustrations. $4.00. Philadelphia: J. B. Lippincott Co , 1957.

WOUNDS
BURNS
PERITONITIS

EFFECTIVE

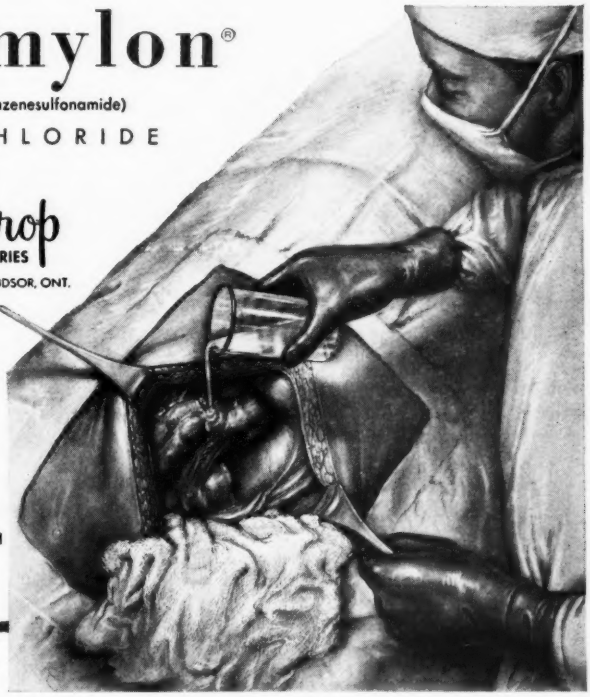
Topical Chemotherapy

Sulfamylon is exceptionally active topically, is not inactivated by pus or blood or change in environmental acidity, and has shown no tendency to produce drug-resistant bacterial strains. Applied as wet dressing, by irrigation, by sponging or pouring into the peritoneal cavity in amounts up to 200 cc.

Sulfamylon®

(4-aminomethylbenzenesulfonamide)
HYDROCHLORIDE

Winthrop
LABORATORIES
NEW YORK 18, N.Y. • WINDSOR, ONT.



Supplied

SULFAMYLON 5% SOLUTION
in bottles of 1 oz.
and 8 oz.

ALSO SULFAMYLON 5% SOLUTION
in bottles of 100 cc.
with vial of streptomycin
20,000 units.

SULFAMYLON 5% VISCOUS SOLUTION
for ear infections,
bottles of 1 oz.

Sulfamylon, trademark reg. U.S. & Canada, brand of mafenide

"...postoperative vomiting was reduced far more with ['Thorazine'] than with seven other drugs and combinations of drugs that were tried in 831 cases."[1]

Available: Ampuls, tablets, syrup and suppositories.

Smith, Kline & French Laboratories, Phila.

THORAZINE

*T.M. Reg. U.S. Pat. Off.

Printed by R. R. Donnelley & Sons Co., Chicago, Illinois, U. S. A.